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(NASA-CR-167768) SPACE OPERATIONS CENTER:
SHUTTLE INTERACTION STUDY EXTENSION. VOLUME
2: APPENDIXES Final Report (Rockwell
International Corp., Downey, Calif.) 164 p
HC A09/MF A01

N83-13144

Unclass
CSCL 22A G3/16 01275

SSD 81-0194

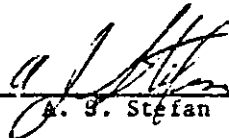
SPACE OPERATIONS CENTER/
SHUTTLE INTERACTION STUDY EXTENSION

FINAL REPORT, VOLUME II
APPENDIXES

Contract No. NAS9-16153
DRL T-1626
Line Item 3

FEBRUARY 1982

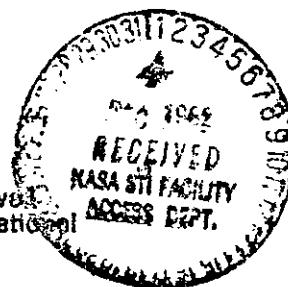
Approved by


A. S. Stefan

Space Operations/Integration &
Satellite Systems Division



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International



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SHUTTLE INTERACTION STUDY EXTENSION

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Rockwell
International

FOREWORD

This report contains the results of the analysis of the additional issues identified in the SOC/Shuttle Interaction Study extension. This data supplements the SOC/Shuttle Interactions identified in the original contracted effort.

This effort was performed under Contract Number NAS9-16153, by the Space Operations and Satellite Systems Division of Rockwell International for the National Aeronautics and Space Administration, Johnson Space Center. The study was administered under the technical direction of the Contracting Officers Representative (COR), Mr. S. H. Nassiff, Program Development Office, Engineering and Development Directorate, Johnson Space Center.

The study was performed under the direction of A. J. Stefan, Study Manager. The following persons made significant contributions to the completion of the analysis.

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B	Servicing Activity Data Sheets
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APPENDIX A

SERVICE FUNCTIONS DEFINITIONS

APPENDIX A

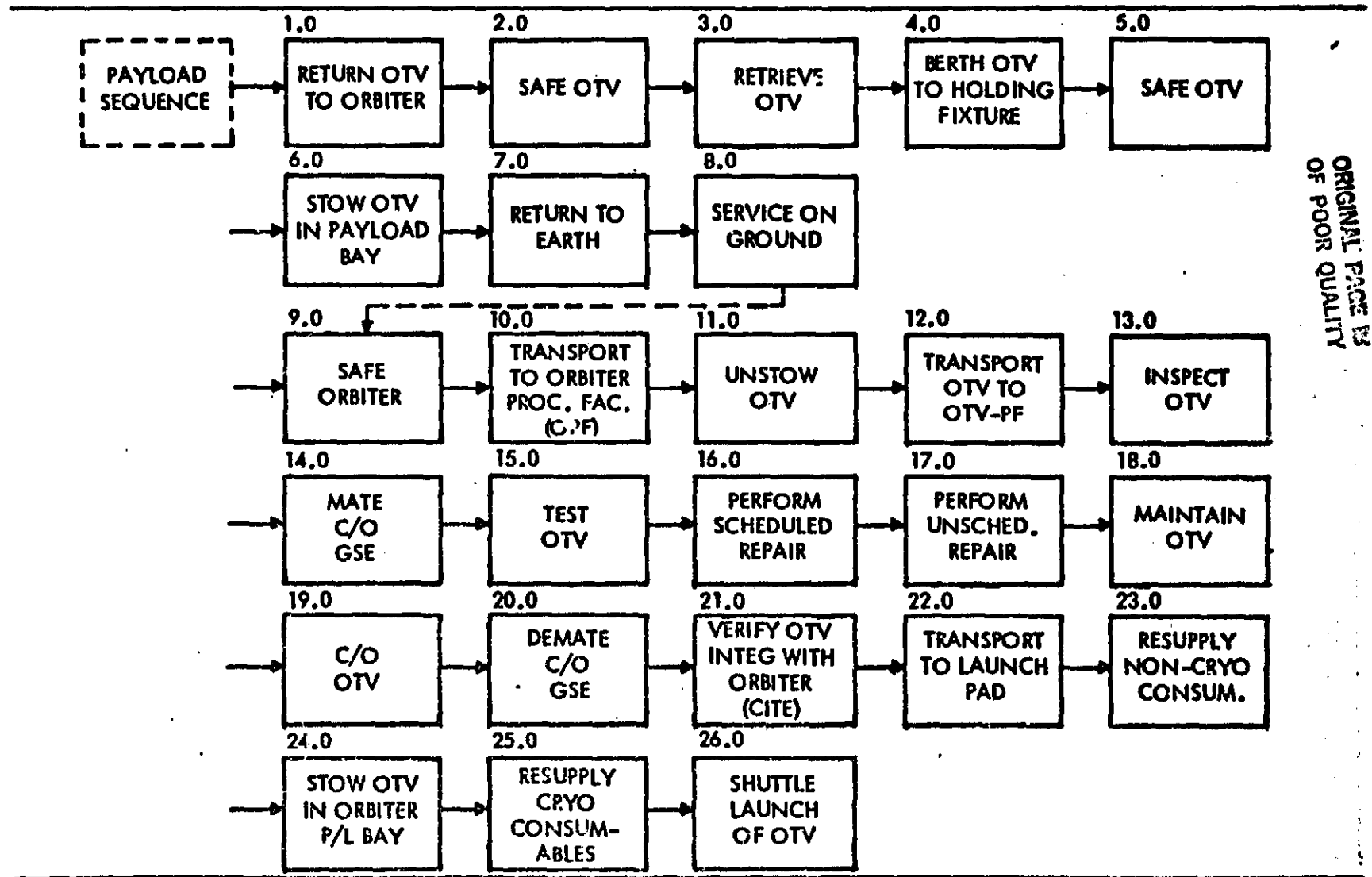
SOC/Shuttle Interaction Extension Study Service Functions Definitions

<u>Function</u>	<u>Definition</u>
Deploy	Extract/reposition payload out of cargo bay, extend/retract appendages. Use a qualifier for further clarification.
Observe/Inspect	Examine, monitor, touch, gather data, investigate, look into.
Manuever	Stabilize, orient, transfer, transport, trim.
Retrieve	Berth, dock, grapple, capture, recover, proximity operations. Use a qualifier for further clarification.
Repair	Remove/replace inoperative parts, restore damaged areas, unscheduled or corrective maintenance.
Maintain	Clean, preserve, adjust, calibrate, align, scheduled or preventive maintenance.
Safe	Fasten/unfasten, tether, latch/unlatch, activate/deactivate, shield/cover, secure, protect.
Checkout/Test	Diagnose/isolate, assess/analyze, self-check, verify, activate/deactivate.
Supply/Resupply	Fuel/refuel, replenish consumables (fluids, batteries).
Reconfigure	Software change, hardware functional change, reliability change.
Override	Extend/retract, open/close, latch/unlatch (remotely or manually).
Return	Return to SOC, return to earth.
Separate	Separation of two spacecrafts from each other, release, disconnect, detach.
Dock	Joining of two spacecrafts by RCS.
Berth	Joining of two spacecrafts by manipulator.
Mate/Demate	Joining/unjoining of two matching interfaces, connect/disconnect.
Stow	Store, reserve, set aside.
Prepare	Make ready, plan, rehearse.

APPENDIX B

SERVICING ACTIVITY DATA SHEETS

OTV -- GROUND SERVICING



B-1

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SERVICING ACTIVITY DATA

SCENARIO: OTV Ground Servicing

ACTIVITY: 11.0 Unstow OTV

DESCRIPTION: Upon landing of the orbiter and its transportation to the Orbiter Processing Facility, its OTV cargo will be unstowed from the payload bay and loaded onto an OTV transporter.

SUPPORT EQUIPMENT:

- (1) Crane for lifting OTV from orbiter.
- (2) OTV transporter.

CREW INVOLVEMENT: None .

SOC PROVISIONS: None .

OTV PROVISIONS: Fittings to interface with crane.

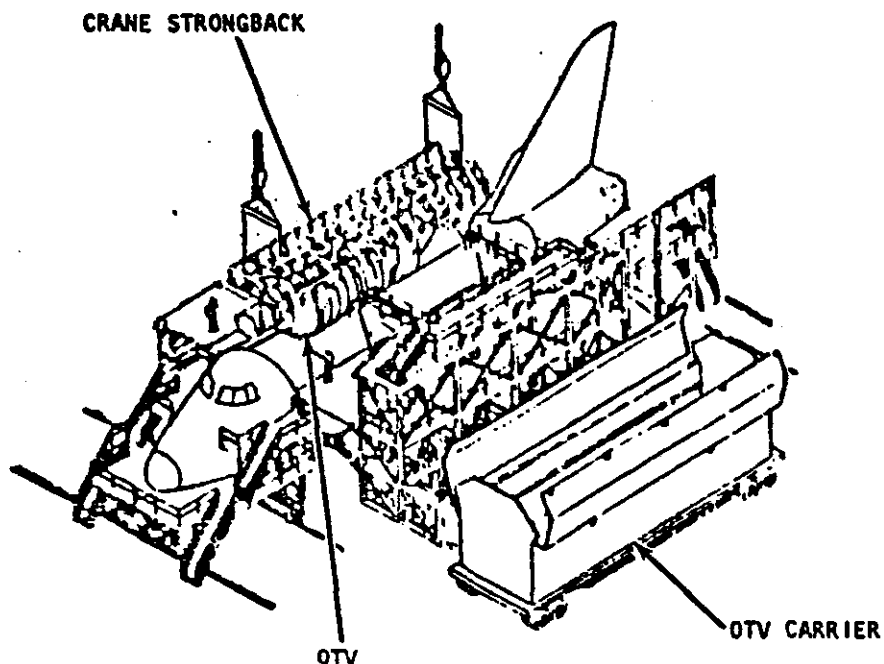
ORBITER PROVISIONS: None .

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SERVICING ACTIVITY DATA

FUNCTION ITEM	OTV Ground Servicing 11.0 Unstow OTV	ATTACHMENT	
		PAGE	

SUBJECT	Selected Method
---------	-----------------



With the orbiter in the Orbiter Processing Facility (OPF), manually attach crane fittings (4) next to longeron trunnions. Release longeron deployable fittings on the orbiter. Crane lifts OTV out of payload bay, separating the electrical umbilical connection, and lowers the OTV into the OTV transporter where the longeron trunnions are recaptured.

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SERVICING ACTIVITY DATA

SCENARIO: OTV Ground Servicing

ACTIVITY: 12.0 Transport OTV to OTV Processing Facility

DESCRIPTION: Within its transporter, the OTV is moved to the OTV Processing Facility where it is unloaded and installed on the OTV Service Fixture for the start of servicing and repair operations.

SUPPORT EQUIPMENT:

- (1) Crane for lifting OTV from transporter to Service Fixture.
- (2) OTV Transporter.
- (3) OTV Service Fixture.

CREW INVOLVEMENT: None.

SOC PROVISIONS: None.

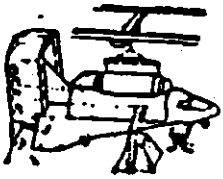
OTV PROVISIONS: Interface compatibility with the service fixture.

ORBITER PROVISIONS: None.

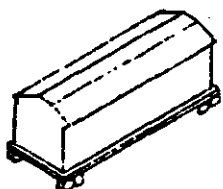
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SERVICING ACTIVITY DATA


FUNCTION	OTV Ground Servicing	ATTACHMENT	
ITEM	12.0 Transport OTV to OTV Proc. Facility	PAGE	
METHOD	Transporter/Crane		
SUBJECT	Selected Method		



ORBITER
PROCESSING
FACILITY



OTV
TRANSPORTER



OTV
SERVICE
FIXTURE

OTV PROCESSING FACILITY

OTV is transported in the OTV transporter to the Processing Facility. A crane (equivalent to 11.0) transfers the OTV to the service fixture. Umbilical interfaces are not connected.

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SERVICING ACTIVITY DATA

SCENARIO: OTV Ground Servicing

ACTIVITY: 13.0 Inspect OTV
14.0 Mate C/O GSE

DESCRIPTION: A complete external inspection of the OTV is the first servicing activity the OTV will undergo after installation into the service fixture. Subsequently, a GSE checkout umbilical will be manually mated to the OTV for further servicing operations.

SUPPORT EQUIPMENT:

- (1) Service Fixture
- (2) GSE Umbilical

CREW INVOLVEMENT: None.

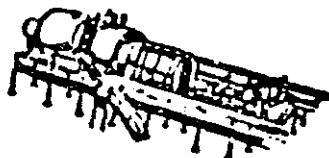
SOC PROVISIONS: None.

OTV PROVISIONS: Interface compatible with GSE.

ORBITER PROVISIONS: None.

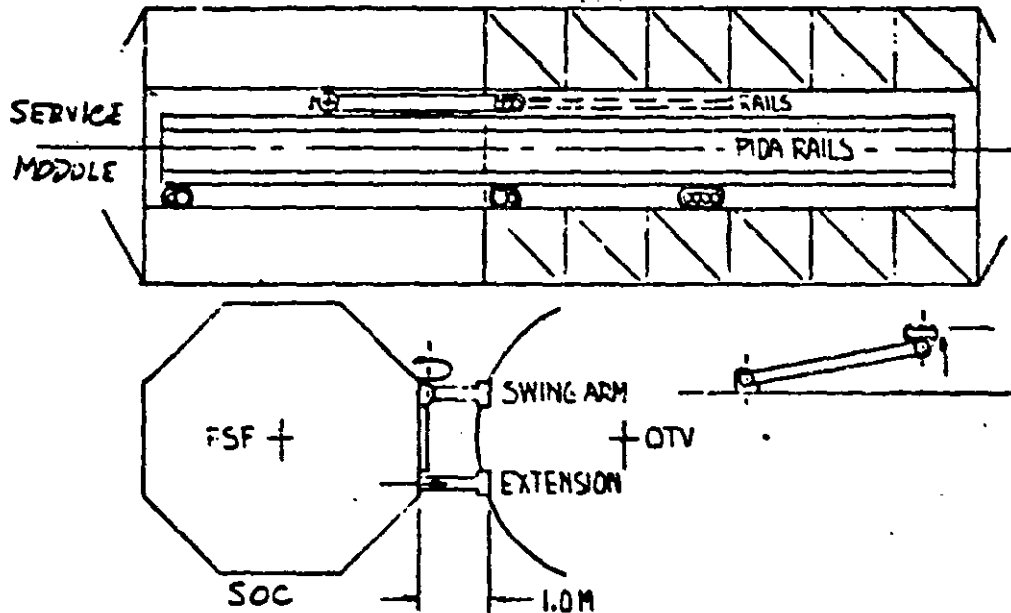
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SERVICING ACTIVITY DATA

FUNCTION ITEM	OTV Ground Servicing 13.0 Inspect OTV & 14.0 Mate C/O GSE	ATTACHMENT	
METHOD	Manual	PAGE	
SUBJECT	Selected Method		
<p data-bbox="759 556 1007 619">ORIGINAL PAGE IS OF POOR QUALITY</p>  <p data-bbox="693 976 966 1008">OTV SERVICE FIXTURE</p>			
<p data-bbox="322 1249 520 1291">13.0 <u>Inspect</u></p> <p data-bbox="421 1312 1329 1375">All accessible external areas are inspected manually for evidence of damage/wear.</p> <p data-bbox="322 1396 660 1428">14.0 <u>Mate OTV With GSE</u></p> <p data-bbox="421 1449 1329 1512">Umbilical interfaces are made by connector extensions duplicating the in-space servicing by SOC.</p> <p data-bbox="421 1533 1230 1596">Connections are visually monitored to verify alignment and attachment.</p> <p data-bbox="421 1617 1329 1680">Additional manual connections may be made to individual LRU's and subassemblies if required.</p>			

SERVICING ACTIVITY DATA

FUNCTION ITEM	OTV Ground Servicing 13.0 Inspect OTV & 14.0 Mate C/O GSE	ATTACHMENT	
METHOD		PAGE	
SUBJECT	Selected Method		



The OTV Service Fixture must duplicate the umbilical connections to be used in space (SOC) to verify the alignment and attachment functions (pull-in, QD leakage, etc.).

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SERVICING ACTIVITY DATA

SCENARIO: OTV Ground Servicing

ACTIVITY: 15.0 Test OTV (Fault Isolation)

DESCRIPTION: A complete systems test will be conducted to checkout the operations of all systems, subsystems and LRU's. The GSE test equipment will interface the OTV through the umbilical on the service structure.

SUPPORT EQUIPMENT:

- (1) Functional Test Station.
- (2) OTV Service Fixture.
- (3) GSE Umbilical.

CREW INVOLVEMENT: None.

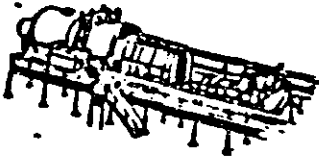
SOC PROVISIONS: None.

OTV PROVISIONS: Interface compatible with GSE.

ORBITER PROVISIONS: None.

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SERVICING ACTIVITY DATA

FUNCTION	OTV Ground Servicing	ATTACHMENT	
ITEM	15.0 Test OTV (Fault Isolation)		
METHOD	Computerized Test	PAGE	
SUBJECT	Selected Method		
<p>ORIGINAL FILED OF POOR QUALITY</p>  <p>OTV SERVICE FIXTURE</p>			
<p>Complete functional tests of the OTV system operations would be made through the electrical umbilical and any other manual connections to verify correctness of operation. Identification would be made of faults in system, LRU, and subassembly operations.</p> <p>Tests would be pre-programmed with manual program accession capability to isolate faults to the lowest level.</p>			

SERVICING ACTIVITY DATA

SCENARIO: OTV Ground Servicing

ACTIVITY: 16.0 Perform Scheduled Repair

DESCRIPTION: Only those LRU's which were scheduled for replacement are removed from the OTV and new units installed.

SUPPORT EQUIPMENT:

- (1) LRU Storage.
- (2) Manual tools for assembly/disassembly.

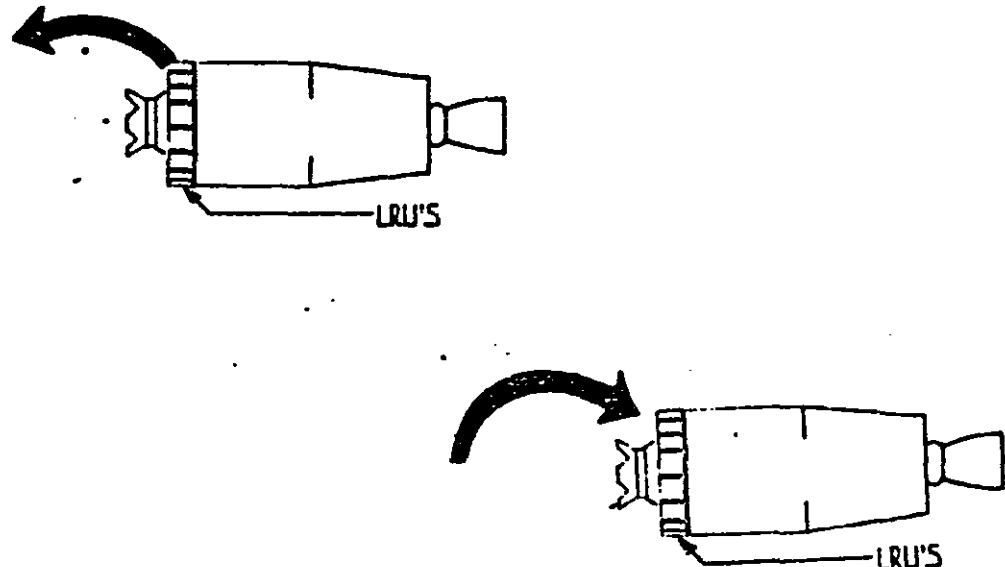
CREW INVOLVEMENT: None.

SOC PROVISIONS: None.

OTV PROVISIONS: None.

ORBITER PROVISIONS: None.

SERVICING ACTIVITY DATA

FUNCTION ITEM	OTV Ground Servicing 16.0 Perform Scheduled Repair	ATTACHMENT	
METHOD	Manual	PAGE	
SUBJECT Selected Method			
			
<p><u>Scheduled Removal of Time Limited LRU's</u></p> <p>Scheduled LRU's are manually disengaged, removed, and transferred to storage.</p> <p><u>Replacement of Time Limited LRU's</u></p> <p>New LRU's are withdrawn from new storage and manually installed and engaged into their assembly locations.</p> <p style="text-align: center;">ORIGINAL PAGE 13 OF POOR QUALITY</p>			

SERVICING ACTIVITY DATA

SCENARIO: OTV Ground Servicing

ACTIVITY: 17.0 Perform Unscheduled Repair

DESCRIPTION: All subsystems, LRU's, structural areas, etc., that were identified in Activities 13.0 and 15.0 as faulty or damaged are repaired and tested at the component level to verify satisfactory performance.

SUPPORT EQUIPMENT:

- (1) Component, LRU Storage.
- (2) Manual Tools.

CREW INVOLVEMENT: None.

SOC PROVISIONS: None.

OTV PROVISIONS: None.

ORBITER PROVISIONS: None.

SERVICING ACTIVITY DATA

FUNCTION ITEM	OTV Ground Servicing 17.0 Perform Unscheduled Repair	ATTACHMENT				
METHOD		PAGE				
SUBJECT	Selected Method					
<div data-bbox="636 659 966 827" data-label="Image"> </div> <div data-bbox="654 827 928 858" data-label="Caption"> <p>OTV SERVICE FIXTURE</p> </div>						
<div data-bbox="252 1234 502 1268" data-label="Section-Header"> <p><u>Manual Operations</u></p> </div> <div data-bbox="252 1289 1290 1415" data-label="Text"> <p>Provide repair/replacement of structures, attached items, components, etc. With active component replacement (connector, valve, etc.) manually check functional operation after replacement (conductivity, open/close activate, etc.).</p> </div> <div data-bbox="667 1625 925 1709" data-label="Text"> <p>ORIGINAL PAGE IS OF POOR QUALITY</p> </div>						

SERVICING ACTIVITY DATA

SCENARIO: OTV Ground Servicing

ACTIVITY: 19.0 Checkout OTV

DESCRIPTION: Functional tests will be conducted to verify system readiness at the OTV Processing Facility.

SUPPORT EQUIPMENT:

- (1) Functional Test Station.
- (2) OTV Service Fixture.
- (3) GSE Umbilical.

CREW INVOLVEMENT: None.

SOC PROVISIONS: None.

OTV PROVISIONS: Interface compatible with GSE.

ORBITER PROVISIONS: None.

SERVICING ACTIVITY DATA

FUNCTION ITEM	OTV Ground Servicing 19.0 Checkout OTV	ATTACHMENT		
METHOD	Computerized Test	PAGE		
SUBJECT	Selected Method			
<div data-bbox="602 703 933 871" data-label="Image"> </div> <div data-bbox="636 892 916 934" data-label="Caption"> <p>OTV SERVICE FIXTURE</p> </div>				
<p data-bbox="247 1218 1230 1249">Complete functional tests of the OTV system operations - same as 15.0.</p> <div data-bbox="652 1533 916 1606" data-label="Text"> <p>ORIGINAL DRAWING OF POOR QUALITY</p> </div>				

SERVICING ACTIVITY DATA

SCENARIO: OTV Ground Servicing

ACTIVITY: 21.0 Verify OTV Integration With Orbiter (CITE)

DESCRIPTION: The OTV must be removed from the service fixture and loaded onto a transporter. It is then carried to the Vertical Processing Facility where it is removed from the cannister and installed into Cargo Integration Test Equipment (CITE) to verify its compatibility with the orbiter payload bay.

SUPPORT EQUIPMENT:

- (1) Crane at OTV Processing Facility & Vertical Processing Facility.
- (2) OTV Transporter.
- (3) CITE.

CREW INVOLVEMENT: None.

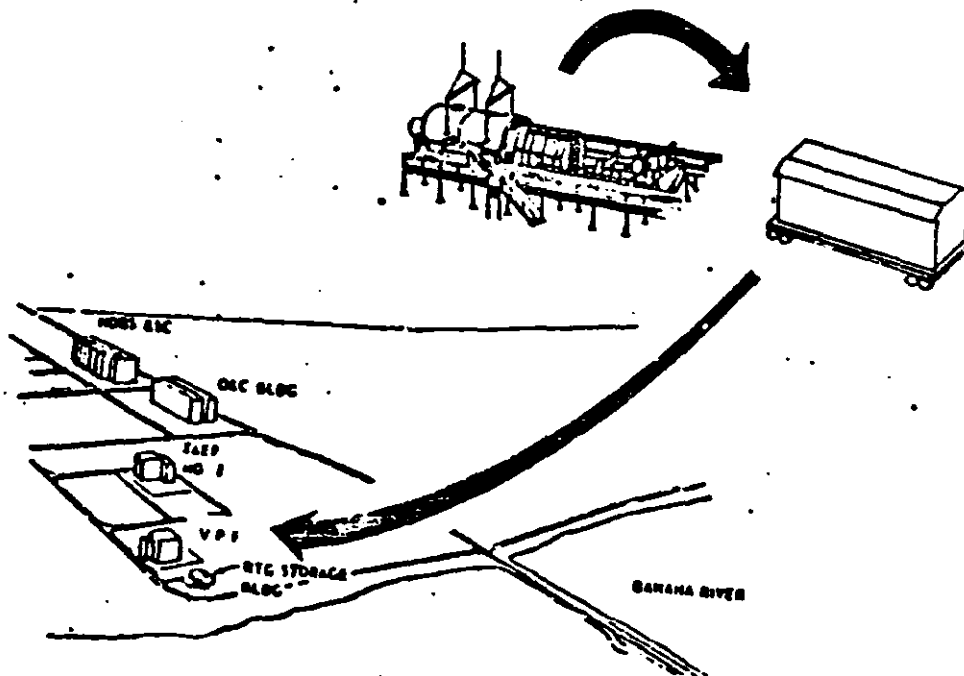
SOC PROVISIONS: None.

OTV PROVISIONS: Compatibility with CITE.

ORBITER PROVISIONS: None.

SERVICING ACTIVITY DATA

FUNCTION	OTV Ground Servicing	ATTACHMENT	
ITEM	21.0 Verify OTV Integration With Orbiter (CITE)		
METHOD		PAGE	
SUBJECT	Selected Method		

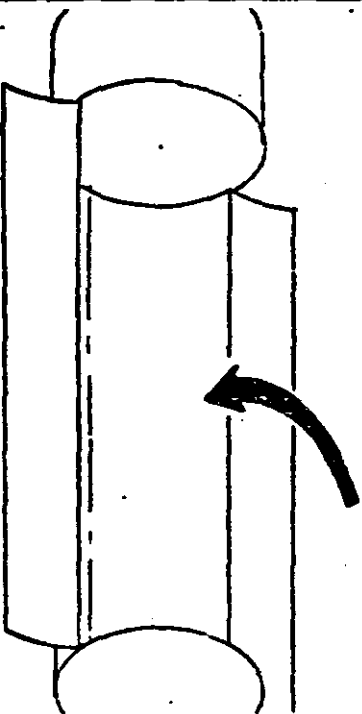


21.1 Transport to Vertical Processing Facility

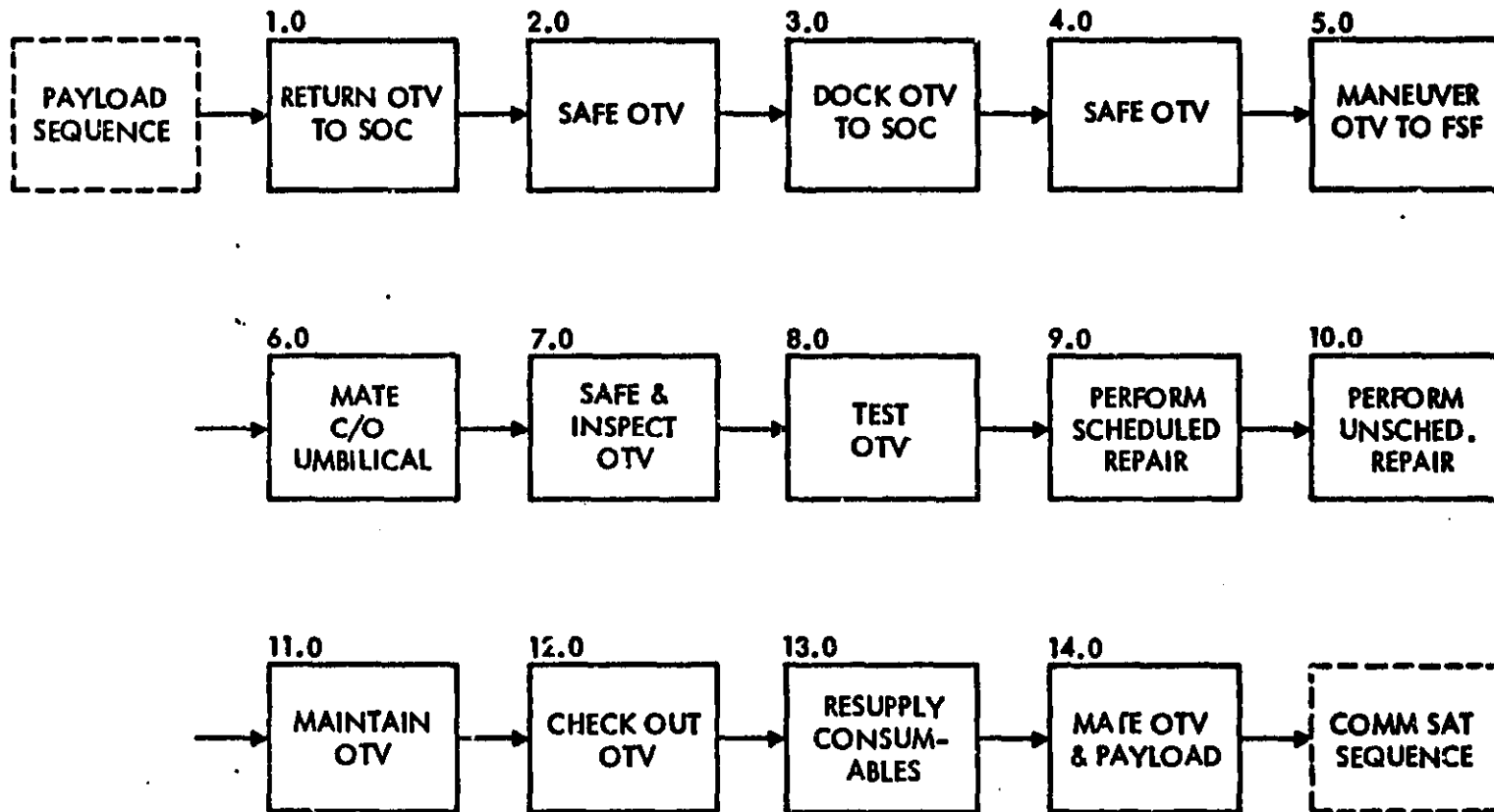
Manually attach crane fittings (4) next to longeron trunnions. Crane lifts OTV out of service fixture and into the payload cannister. Payload cannister is transported with OTV to Vertical Processing Facility.

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SERVICING ACTIVITY DATA

FUNCTION ITEM	OTV Ground Servicing 21.0 Verify OTV Integration With Orbiter (CITE)	ATTACHMENT	
METHOD		PAGE	
SUBJECT	Selected Method		
			
<p>21.2 OTV is removed from payload cannister and installed into cargo integration test equipment (CITE). (Payload bay mockup).</p> <p>21.3 All OTV/orbiter interfaces are checked for correctness.</p> <p style="text-align: center;">ORIGINAL PAGE IS OF POOR QUALITY</p>			

OTV -- SOC SERVICING



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SERVICING ACTIVITY DATA

SCENARIO: OTV/SOC Servicing

ACTIVITY: 1.0 Return OTV to SOC

DESCRIPTION: Upon the completion of a mission, a space-based OTV returns to its base, the SOC for refurbishment, refueling and mating to another payload as a prelude to the start of another mission.

SUPPORT EQUIPMENT:

Control and Monitor Station.

CREW INVOLVEMENT:

IVA crewmen to operate the control and monitor station.

SOC PROVISIONS:

OTV control and monitor station.

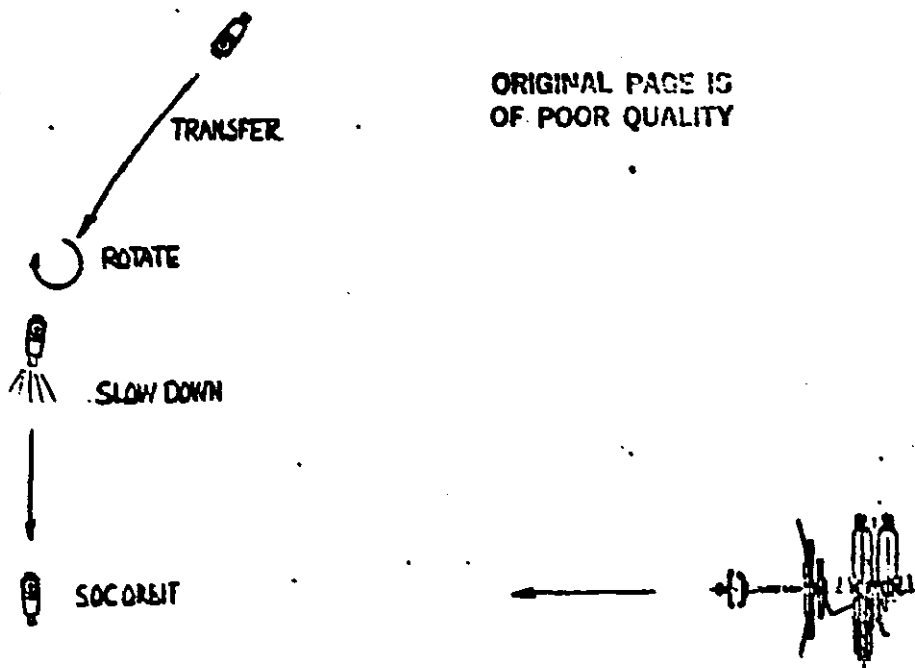
OTV PROVISIONS:

Communications and data link with SOC and ground control station.

ORBITER PROVISIONS: None.

SERVICING ACTIVITY DATA

FUNCTION ITEM	OTV/SOC Servicing 1.0 Return OTV to SOC	ATTACHMENT	
METHOD	Programmed Schedule/Update	PAGE	
SUBJECT	Selected Method		



Following the transport and release of the payload to its GEO orbit, the OTV will be returned to the SOC orbit by a pre-programmed schedule with update and corrections transmitted from ground-based or space-based control stations not necessarily involving SOC control.

- o M.E. thruster turned on to approach SOC orbit on a non-collision course.
- o M.E. thruster turned off at a pre-determined velocity.
- o OTV rotated for retrograde thrust.
- o M.E. thruster turned on to stop OTV at SOC orbit in proximity to SOC.
- o Main engine shutoff.

SERVICING ACTIVITY DATA

FUNCTION ITEM	OTV/SOC Servicing 1.0 Return OTV to SOC	ATTACHMENT	
METHOD		PAGE	
SUBJECT			
<p>If SOC is configured to assume control, monitoring, and correction of the orbit transfer of OTV payload by the OTV, it would also be practical for SOC to control the return orbit transfer of the OTV.</p> <p>More likely the transfers will be ground controlled directly or through satellite relay stations.</p> <p>Return transfer would be to an orbit consistent with the SOC orbit at a location possibly 5 to 20 n.mi from the SOC in a direction from which the SOC could maintain control over the subsequent closure transfer.</p> <p>An IVA manned SOC control console station with antenna control and data transfer is required for this, and subsequent activities.</p>			

SERVICING ACTIVITY DATA

SCENARIO: OTV/SOC Servicing

ACTIVITY: 2.0 Safe OTV

DESCRIPTION: While the OTV is parked in the proximity of the SOC upon return from a mission, it is safed for subsequent docking to the SOC. Safing operations are controlled automatically from the OTV control and monitor station on-board the SOC.

SUPPORT EQUIPMENT:

Control and Monitor Station.

CREW INVOLVEMENT:

IVA crewmen to control safing operations.

SOC PROVISIONS:

OTV control and monitor station.

OTV PROVISIONS:


Communications and data link with SOC and ground control station.

ORBITER PROVISIONS: None.

SERVICING ACTIVITY DATA

FUNCTION	OTV/SOC Servicing	ATTACHMENT	
ITEM	2.0 Safe OTV		
METHOD	SOC Control	PAGE	
SUBJECT	Selected Method		

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Following the return of the OTV to a relatively stable location in the SOC orbit, the SOC will assume transmission control of the OTV.

- o ACPS turned on to verify reaction control function capability.
- o OTV main propulsion system safed.
 - Shut off main engine isolation valves and verify.
 - Shut off cryo isolation valves and verify.

SERVICING ACTIVITY DATA

FUNCTION ITEM	OTV/SOC Servicing 2.0 Safe OTV	ATTACHMENT		
METHOD		PAGE		
SUBJECT				
<p>Main propulsion system would be safed prior to closure transfer to prevent any unauthorized main engine thrust during the approach to SOC.</p> <p>The main propulsion system would not be safed until ACPS control is established on the contingency that failure to assume ACPS control may require main engine operation to move the OTV away from the SOC orbit to prevent collision.</p> <p>Normal safing of main engine tanks would not be performed here in order to maintain and conserve expendables. Contingency dump and purge activity by remote SOC control would be available if status feedback indicated a dangerous condition.</p>				

SERVICING ACTIVITY DATA

SCENARIO: OTV/SOC Servicing

ACTIVITY: 3.0 Dock OTV to SOC
4.0 Safe OTV

DESCRIPTION: The docking operation requires pulsing of the ACPS to effect a hard dock of the OTV to the service fixture of the SOC Flight Support Facility. Upon verification of docking, the OTV ACPS must be safed prior to the initiation of any other OTV related activity.

SUPPORT EQUIPMENT:

- (1) Control and Monitor Station.
- (2) Docking Port.

SUPPORT EQUIPMENT:

IVA crewmen to control docking and safing operations.

SOC PROVISIONS:

- (1) OTV control and monitor station.
- (2) Docking port on FSF.
- (3) Instrumentation for docking verification.

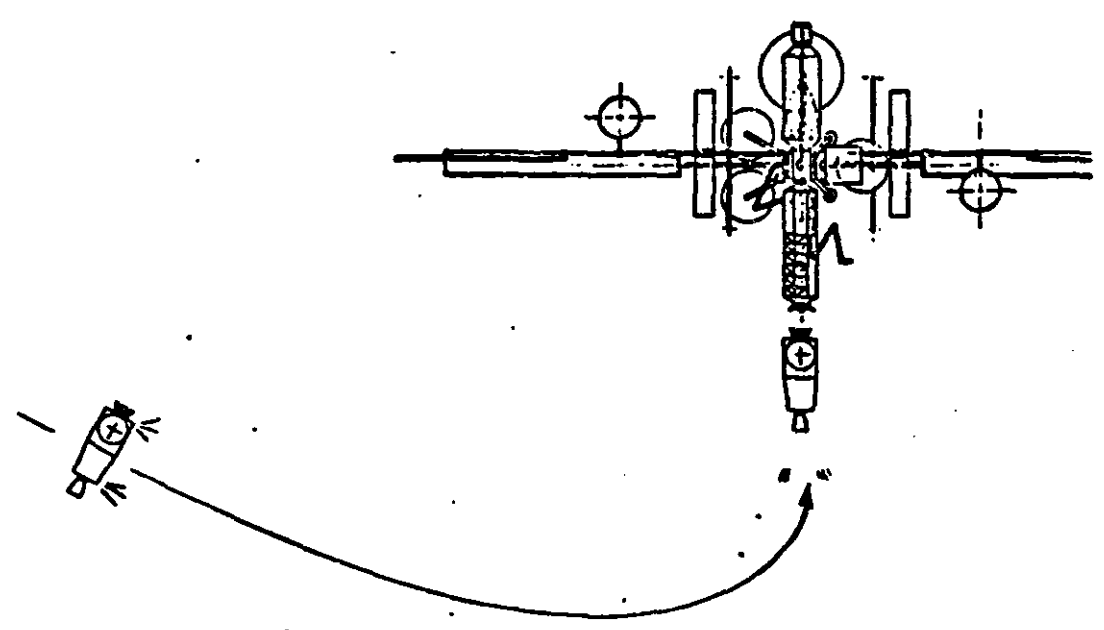
OTV PROVISIONS:

- (1) Communications link with SOC and ground control station.
- (2) Docking port.

ORBITER PROVISIONS: None.

SERVICING ACTIVITY DATA

FUNCTION	OTV/SOC Servicing	ATTACHMENT	
ITEM	3.0 Dock OTV to SOC & 4.0 SAFE OVT	PAGE	
METHOD	SOC Control of ACPS		
SUBJECT	Selected Method		



OTV is under transmission control by SOC.

- o ACPS turned on to approach SOC on a non-collision course.
- o ACPS turned off at a pre-determined velocity.
- o ACPS turned on to stop OTV at close proximity to SOC (200m).
- o ACPS operated in conjunction with a dock monitoring system to maneuver OTV and effect a hard dock to the docking port at the outer end of the service fixture.
- o ACPS turned off and safed.

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SERVICING ACTIVITY DATA

SCENARIO: OTV/SOC Servicing

ACTIVITY: 3.0 Maneuver OTV to FSF

DESCRIPTION: Once docked to the FSF, the OTV must be transported to the FSF side where repair and maintenance operations can be conducted.

SUPPORT EQUIPMENT:

- (1) Manipulator
- (2) Grapple Fixture
- (3) PIDA Interfaces (2)

CREW INVOLVEMENT:

IVA crewmen to control OTV transfer operations to the FSF side.

SOC PROVISIONS:

- (1) Manipulator on FSF.
- (2) PIDA interfaces (2) on translation rail.

OTV PROVISIONS:

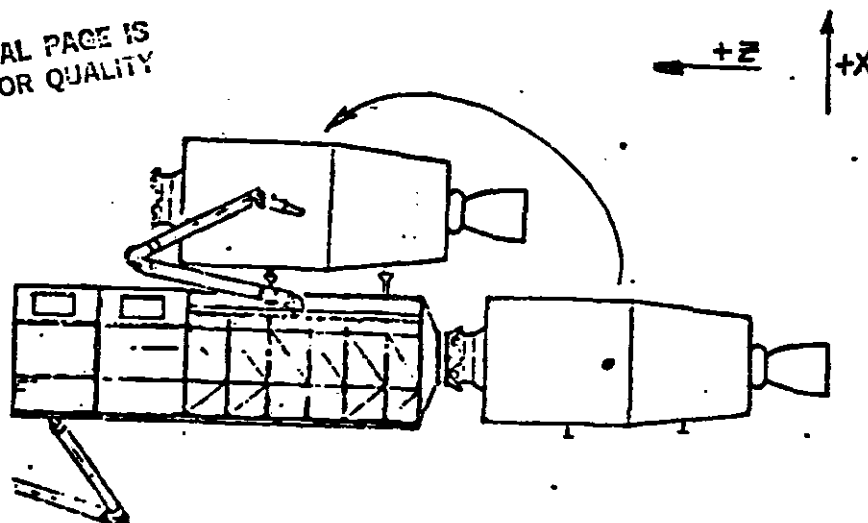
- (1) Grapple Fixture
- (2) PIDA Interfaces (2)

ORBITER PROVISIONS: None.

SERVICING ACTIVITY DATA

FUNCTION ITEM	OTV/SOC Servicing 5.0 Maneuver OTV to FSP	ATTACHMENT	
METHOD	Mobile Servicing Manipulator System	PAGE	
SUBJECT	Selected Method		

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OTV is docked and safed in activities 3.0 and 4.0.

- (1) SF manipulator arm (either side) attaches its end effector to a grapple fixture (TBD) on a side normal to the OTV PIDA interfaces.
- (2) SF docking port latches are released.
- (3) OTV is backed off $-Z$, translated $+X$ and $+Z$, and docked $-X$ onto the SF carrier support PIDA docking interfaces.
- (4) Manipulator arm releases grapple fixture.
- (5) SOC maintains remote control and monitoring of OTV.

SERVICING ACTIVITY DATA

SCENARIO: OTV/SOC Servicing

ACTIVITY: 6.0 Mate Umbilicals

DESCRIPTION: Once the OTV is berthed to the sides of the PSP, checkout and servicing umbilicals are deployed and connect to the OTV. Several umbilicals are required as described on the attached sketches.

SUPPORT EQUIPMENT:

Umbilical Systems (4)

CREW INVOLVEMENT:

IVA crewman to connect umbilicals remotely.

SOC PROVISIONS:

Umbilicals Systems (4).

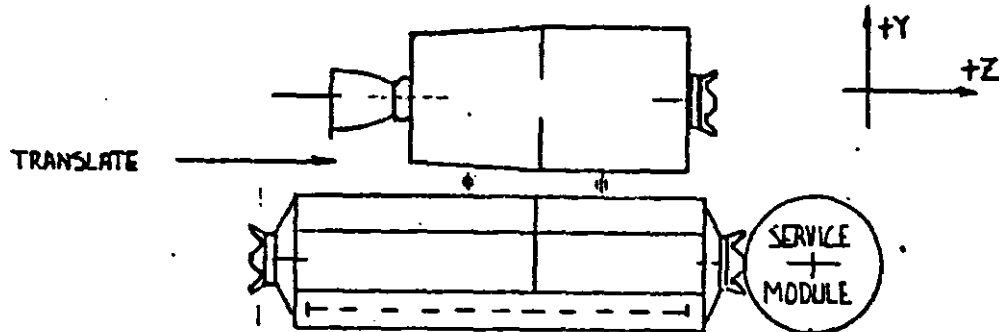
OTV PROVISIONS:

Umbilical Interfaces.

ORBITER PROVISIONS: None.

SERVICING ACTIVITY DATA

FUNCTION	OTV/SOC Servicing	ATTACHMENT	
ITEM	6.0 Mate OTV Umbilicals	PAGE	
METHOD	Service Fixture Umbilical		
SUBJECT	Selected Method		

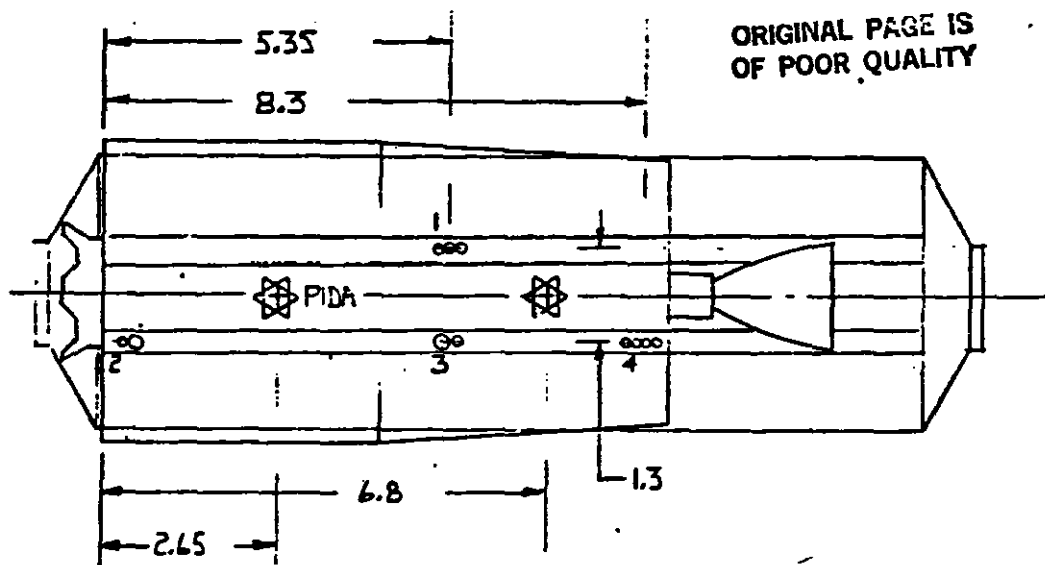


- (1) Service fixture carrier positions OTV to checkout station.
- (2) Checkout umbilicals are extended from the service fixture and umbilicals are inserted to make connection with OTV.

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SERVICING ACTIVITY DATA

FUNCTION ITEM	OTV/SOC Servicing 6.0 Mate OTV Umbilicals	ATTACHMENT	
METHOD	Service Fixture Umbilicals	PAGE	
SUBJECT	OTV Requirements		



OTV requires four umbilical connections. Figure shows connections looking down through the OTV into the service fixture. Connections are on the far side of the OTV.

#1 Electrical Connections - 3 Connectors

- digital control & monitoring
- hardwired C&M backup
- power

#2 LH₂ Connections - Quick Disconnect

- Fill & drain 2 in. line
- Purge 1 in. line

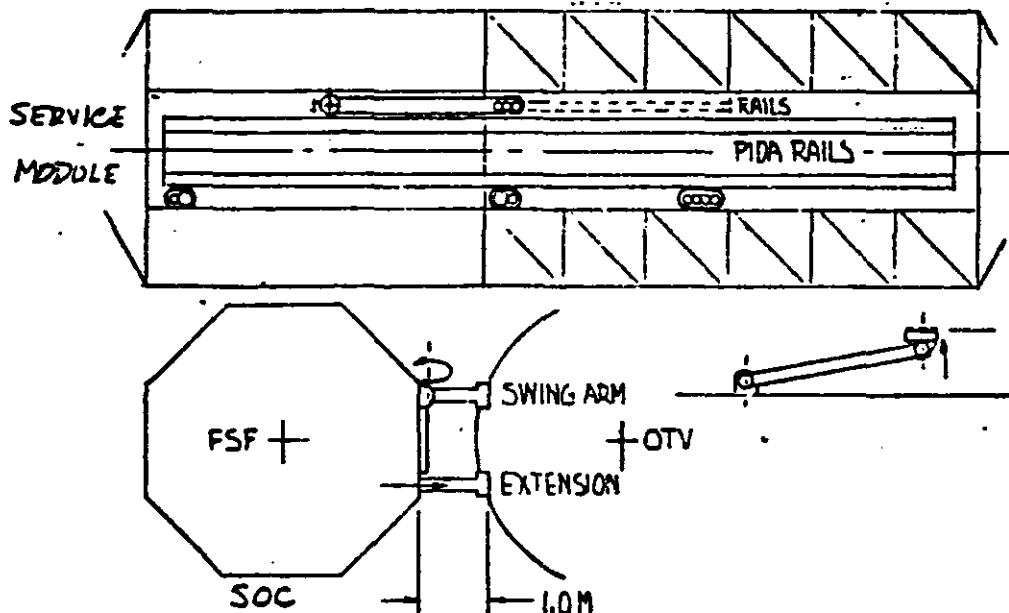
#3 LOX Connections - Quick Disconnect

- Fill & drain 2 in. line
- Purge 1 in. line

- #4 GN₂ Fill & Drain 1 in. line
- ACPS Fill & Drain 1 in. line
- ACPS Purge 1 in. line
- H₂ Fill & Drain 1 in. line

SERVICING ACTIVITY DATA

FUNCTION ITEM	OTV/SOC Servicing 6.0 Mate OTV Umbilicals	ATTACHMENT	
METHOD		PAGE	
SUBJECT	SOC Requirements		



Four umbilical sets on the service fixture between the PIDA rails and the FSF corner.

The LH₂ umbilical in the storage deck area, the LOX umbilical and the GN₂ ACPS and H₂ umbilicals in the tankage area are fixed in location to mate with the OTV at the servicing station. They extend from inside the FSF approximately 1 meter to engage the OTV.

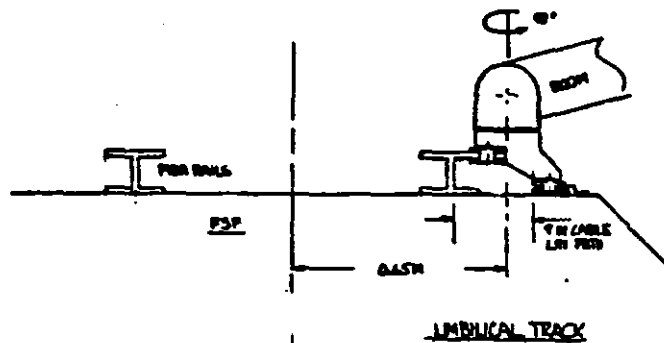
The fluid umbilicals are serviced by flexible hoses. The FSF contains distribution/manifolding lines with valving and pumps to the stowage tanks.

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SERVICING ACTIVITY DATA

FUNCTION	OTV/SOC Servicing	ATTACHMENT	
ITEM	6.0 Mate OTV Umbilicals		
METHOD	Service Fixture Umbilicals	PAGE	
SUBJECT	SOC Requirements		

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All SF umbilicals are with power pull-in after initial alignment and contact. The fluid umbilicals are stationary to mate with the OTV only at the check-out station.

The electrical umbilical is on a swing arm located between the PIDA rails and the service fixture corner. The arm is on a track, using the outer flange of the PIDA rail as shown. Normal stowage of the arm is down against the FSF parallel to the tracks.

The umbilical has four degrees of freedom:

- (1) Linear tracking along the FSF.
- (2) Swing rotation about the X-axis to engage the lower surface of the OTV.
- (3) 90° rotation at the base, about the Y-axis to follow the OTV in later maneuvers.
- (4) 215° rotation at the end of the arm to follow the OTV in later rotations.

SERVICING ACTIVITY DATA

SCENARIO: OTV/SOC Servicing

ACTIVITY: 7.0 Safe and Inspect OTV

DESCRIPTION: The OTV must be safed and inspected prior to the initiation of any repair activities. This entails checkout of systems and assessment of damages, if any, safing the individual systems, and inspecting the interior and exterior of the OTV.

SUPPORT EQUIPMENT:

- (1) Non-propulsive purge system.
- (2) Storage system for OTV expendables.
- (3) Manipulators (2) with CCTV cameras.
- (4) CCTV Monitors.
- (5) Manned Remote Working Station (open cherry picker).
- (6) Manned Maneuvering Unit (MMU).

CREW INVOLVEMENT:

- (1) IVA crewman to operate FSF controls.
- (2) EVA crewman to man OCP or MMU.

SOC PROVISIONS:

- (1) Non-propulsive purge system.
- (2) Third storage containers and associated fluid systems.
- (3) Manipulators with CCTV cameras.
- (4) CCTV monitors.
- (5) Storage for OCP and MMU.

OTV PROVISIONS:

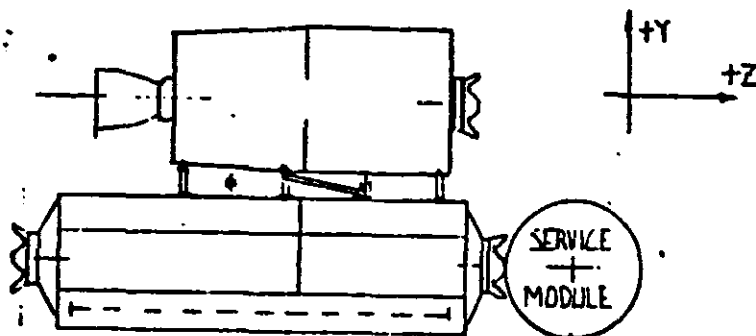
- (1) Accessibility design for inspection purposes.
- (2) Automatic system checkout capability.

ORBITER PROVISIONS: None.

SERVICING ACTIVITY DATA

FUNCTION	OTV/SOC Servicing	ATTACHMENT	
ITEM	7.0 Safe and Checkout of OTV	PAGE	
METHOD	SOC Control of Services		
SUBJECT	Selected Method		

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With umbilicals connected, SOC assumes direct control of the OTV. OTV remains at C/O station.

- (1) Preliminary verification of connection control and status feedback functions.
- (2) Shutdown antenna control and data transfer.
- (3) Shutdown OTV power system.
- (4) Extend expulsion jet arm from service fixture.
- (5) Transfer Expendables to SOC storage tanks purge and vent OTV tankage systems.

(a) Main Engines

Purge main engine using H_2
Purge LH_2 tank and lines using H_2
Purge LO_2 tank and lines using H_2 or N_2
Vent H_2 tank and lines

SERVICING ACTIVITY DATA

FUNCTION ITEM	OTV/SOC Servicing 7.0 Safe and Checkout of OTV	ATTACHMENT		
METHOD	SOC Control of Services	PAGE		
SUBJECT	Selected Method (Cont'd)			
<p>(b) ACPS</p> <p>Purge N₂ and MMH tanks using H₂</p> <p>Purge thrusters and lines using H₂</p> <p>(c) Electric Power System</p> <p>Vent H₂ and O₂ tanks</p> <p>Vent H₂O tank</p> <p>(6) Retract expulsion jet arm. Retract fluid umbilicals.</p> <p>(7) Perform functional checkout on OTV functions with pre-programmed test software, through electrical umbilical.</p>				

SERVICING ACTIVITY DATA

FUNCTION ITEM	OTV/SOC Servicing 7.0 Safe OTV	ATTACHMENT		
METHOD	SOC Control of Services	PAGE		
SUBJECT	Rationale			
<p>Safing is performed in sequence of worst failure condition since the OTV is unmanned and all controls are remote in the SOC.</p>				
<ul style="list-style-type: none"> (1) Isolate main engine operation (performed in Function 2). (2) Isolate ACPS operation (Function 3). (3) Bypass OTV power system. (4) Transfer expendables. (5) Purge and vent main engine system. (6) Purge and vent ACPS system. (7) Vent electrical system. 				
<p>All systems are safed prior to checkout.</p>				

SERVICING ACTIVITY DATA

FUNCTION ITEM	OTV/SOC Servicing 7.0 Safe & Checkout OTV	ATTACHMENT	
		PAGE	
METHOD			
SUBJECT	SOC Requirements		

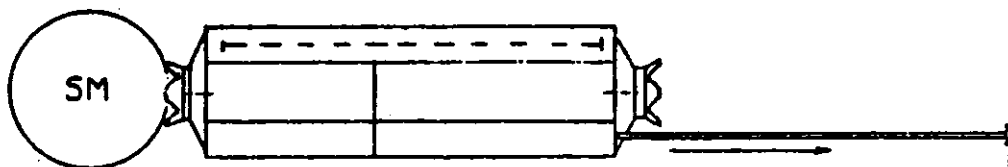


FIG 1

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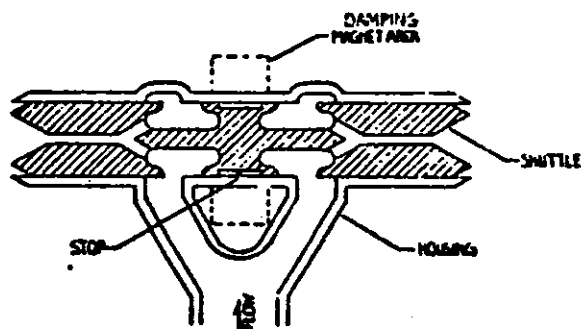


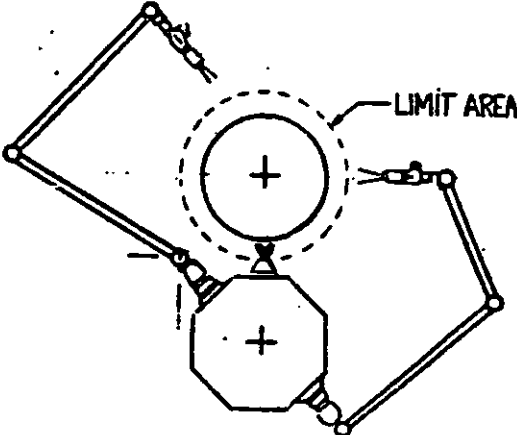
FIG 2

An expulsion system for purge and vent of OTV expandables tanks:

Figure 1: An expulsion arm, extendable from the service fixture to transmit overboard gasses away from the SOC to minimize or prevent contamination.

Figure 2: A non-reactive jet to minimize or prevent reaction forces against the SOC assembly. Outboard ends of free-floating Shuttle absorb all reaction forces such that the output orifices meter the flow of gasses to center the Shuttle at a location resulting in a balanced reaction.

SERVICING ACTIVITY DATA

FUNCTION ITEM	OTV/SOC Servicing 7.0 Inspect OTV	ATTACHMENT		
METHOD	CCTV	PAGE		
SUBJECT Selected Method				
<p data-bbox="789 436 1037 499">ORIGINAL PAGE IS OF POOR QUALITY</p> 				
<p data-bbox="294 1213 1311 1266">Inspection and control at SOC control center by closed-circuit telescopic TV.</p> <p data-bbox="294 1283 1339 1335">Inspection program includes limit values to restrict the manipulator and/or camera to the area 1 meter outside the OTV.</p> <p data-bbox="294 1352 1323 1383">CCTV changeout is required to shift from +X manipulator to -X manipulator.</p> <p data-bbox="294 1394 1224 1425">Inspection is limited to assessment of external damage/or failures.</p>				

SERVICING ACTIVITY DATA

FUNCTION ITEM	OTV/SOC Servicing 7.0 Inspect OTV	ATTACHMENT	
METHOD	SF Manipulator/Manned Cherry Picker	PAGE	
SUBJECT	Alternate Method #1		

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OTV remains at checkout station. Electrical umbilical remains connected. Inspection is performed by EVA on a cherry picker.

Access to all of the foreword (+X) areas of the OTV is by the service fixture manipulator tracking along its carrier over the length of the OTV.

Access to the reverse (-X) areas is by the service fixture manipulator on the opposite side tracking along its own carrier.

Inspection is extended to tactile assessment of external damage/or failures.

SERVICING ACTIVITY DATA

FUNCTION ITEM	OTV/SOC Servicing 7.0 Inspect OTV	ATTACHMENT		
METHOD	MMU	PAGE		
SUBJECT Alternative Method #2				
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<p>Same as Alternative Method #1, except that the FSF manipulator system is not required.</p> <p>Inspection is further extended to areas that may be inaccessible to the cherry picker such as between the body and the main engine cone.</p>				

SERVICING ACTIVITY DATA

SCENARIO: OTV/SOC Servicing.

ACTIVITY: 8.0 Test OTV

DESCRIPTION: A complete test of the OTV will be conducted to assess its status and health and for scheduling of corrective and preventive maintenance operations.

SUPPORT EQUIPMENT:

Test Umbilical.

CREW INVOLVEMENT:

IVA crewman to conduct OTV testing.

SOC PROVISIONS:

Test Umbilical.

OTV PROVISIONS:

Umbilical Interface.

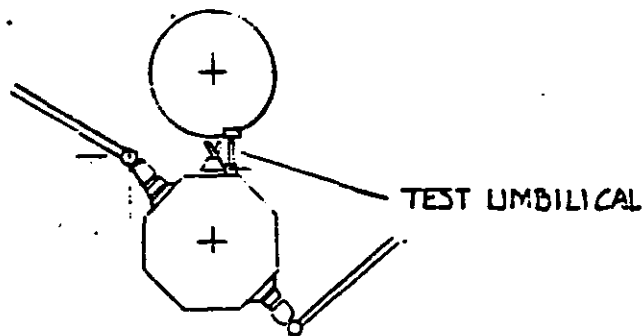
ORBITER PROVISIONS: None.

SERVICING ACTIVITY DATA

FUNCTION ITEM	OTV/SOC Servicing 8.0 Test OTV	ATTACHMENT	
		PAGE	
METHOD	Test Umbilical		
SUBJECT	Selected Method		



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The test umbilical provides data monitoring and operational control signals for test of on-board OTV monitoring.

Test and checkout can be pre-programmed, and manual selection by SOC test operator.

Tests are performed to identify repair/replacement requirements prior to maintaining storage.

SERVICING ACTIVITY DATA

SCENARIO: OTV/SOC Servicing

ACTIVITY: 9.0 Perform Scheduled Repair

DESCRIPTION: Prescheduled preventive maintenance and repair will be performed on the OTV. OTV must be designed for modular (LRU) replacement of parts and components to minimize the number of extraction/reinstallation operations. Storage of spare LRU must be provided by SOC

SUPPORT EQUIPMENT:

- (1) LRU Storage/Retrieval System.
- (2) LRU Extraction/Reinstallation System.
- (3) Manipulator.

SOC PROVISIONS:

- (1) LRU Storage/Retrieval System.
- (2) LRU Extraction/Reinstallation System.
- (3) Manipulator.

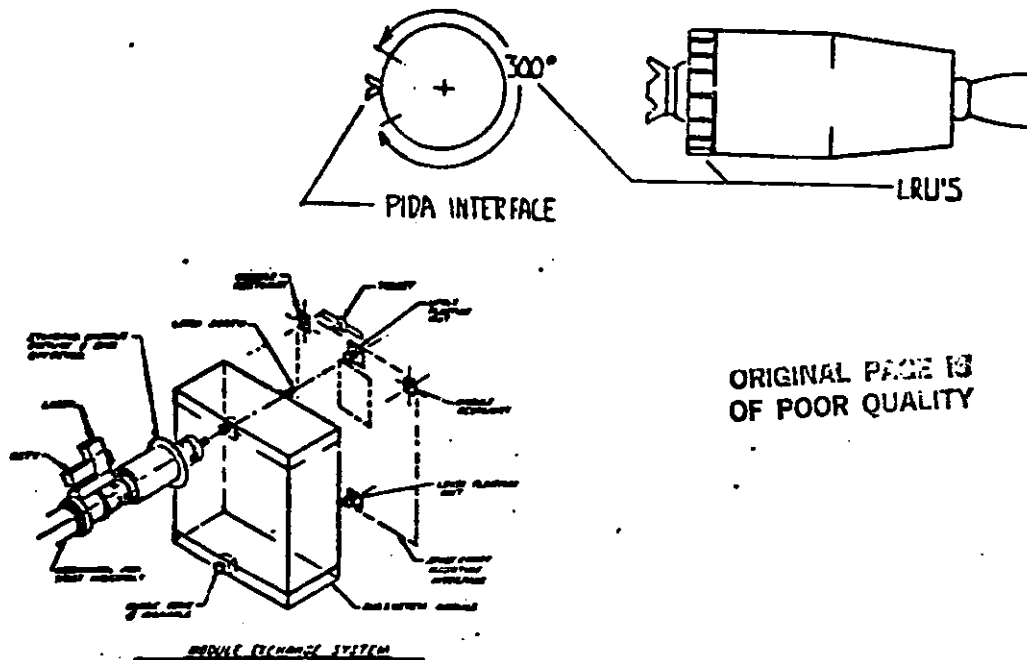
OTV PROVISIONS:

- (1) Modular Design of Parts and Components.
- (2) Accessibility.

ORBITER PROVISIONS: None.

SERVICING ACTIVITY DATA

FUNCTION ITEM	OTV/SOC Servicing 9.0 Scheduled Repair	ATTACHMENT	
METHOD	Remote SF Manipulator	PAGE	
SUBJECT	Selected Method		



Consists of scheduled replacement of subsystem modules.

Module LRU's are periferally mounted in the front of the LH₂ tank at the forward end; over an angle accessible while the OTV is mounted on the service fixture at the PIDA interfaces.

- (1) The SF manipulator arm with a special purpose end effector is remotely controlled to remove and replace scheduled modules.
- (2) Modules are stored and retrieved from the SF storage deck.

SERVICING ACTIVITY DATA

SCENARIO: OTV/SOC Servicing

ACTIVITY: 10.0 Perform Unscheduled Repair

DESCRIPTION: Corrective maintenance will be performed on damaged surfaces and malfunctioning LRU and/or components that were uncovered during inspection and testing activities. Modular components will be replaced remotely in a similar manner to that of Activity 9.0. EVA will be required to repair those surfaces and components that are not amenable to remote operations.

SUPPORT EQUIPMENT:

- (1) Space Ports.
- (2) Open Cherry Picker & MMU.
- (3) Manipulator.

SOC PROVISIONS:

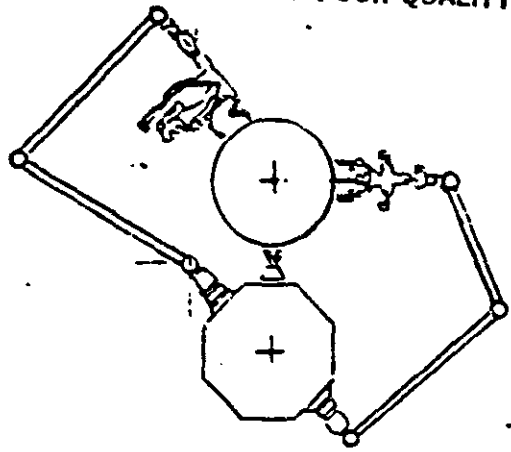
- (1) Storage for spare parts, OCP and MMU.
- (2) Manipulator.

OTV PROVISIONS:

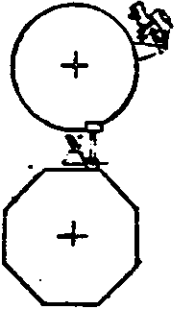
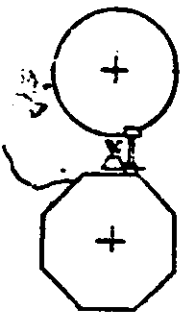
- (1) Modular Design of parts and components.
- (2) Accessibility.

ORBITER PROVISIONS: None.

SERVICING ACTIVITY DATA

FUNCTION ITEM	OTV/SOC Servicing 10.0 Unscheduled Repair	ATTACHMENT	
METHOD	SF Manipulator/Manned Cherry Picker	PAGE	
SUBJECT Selected Method			
<p data-bbox="809 514 1065 588">ORIGINAL PAGE IS OF POOR QUALITY</p> 			
<p data-bbox="313 1302 1296 1365">Replacement of assemblies or components not in the turnaround schedule scenario because of malfunction or damage.</p> <p data-bbox="313 1375 867 1407">Repair of components because of damage.</p> <p data-bbox="313 1417 1354 1470">EVA performs repair or replacement using the cherry picker as an operating station.</p>			

SERVICING ACTIVITY DATA

FUNCTION ITEM	OTV/SOC Servicing 10.0 Unscheduled Repair	ATTACHMENT	
METHOD	MMU and/or Tethered EVA	PAGE	
SUBJECT Alternative Method			
<p style="text-align: center;">ORIGINAL PAGE IS OF POOR QUALITY</p> <div style="display: flex; justify-content: space-around; align-items: center;">   </div>			
<p>EVA performs repair or replacement using OTV handholds for stability. Tethered EVA, although more difficult to provide transport to a repair site, is assumed to have greater accessibility to remote and confined areas.</p>			

SERVICING ACTIVITY DATA

SCENARIO: OTV/SOC Servicing

ACTIVITY: 11.0 Maintain OTV

DESCRIPTION: If the OTV is to await its next mission after being serviced, it must be maintained in a state of readiness. Systems that will maintain the OTV will be activated and its health status will be monitored periodically. Response to any and all contingencies will also be part of this activity.

SUPPORT EQUIPMENT: Electrical Umbilical.

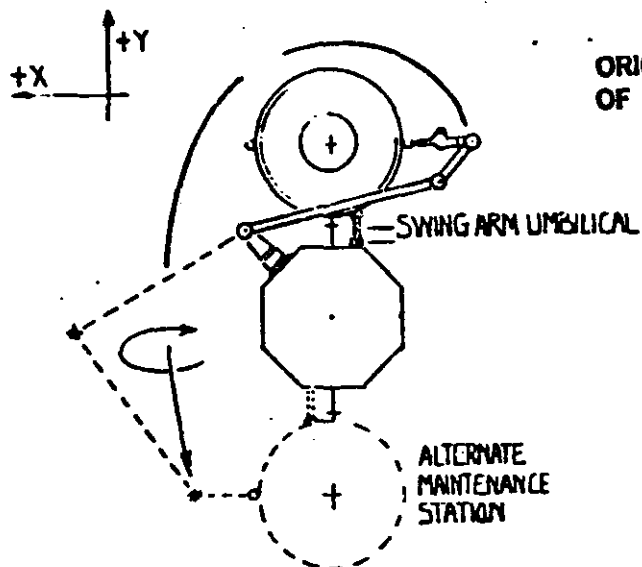
SOC PROVISIONS: Electrical Umbilical.

OTV PROVISIONS: Interface for Electrical Umbilical.

ORBITER PROVISIONS: None.

SERVICING ACTIVITY DATA

FUNCTION	OTV/SOC Servicing	ATTACHMENT	
ITEM	11.0 Maintain OTV & Monitor	PAGE	
METHOD			
SUBJECT	Selected Method		



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- (1) OTV remains at checkout station with electric umbilical connected.
- (2) SOC control station switches to maintenance software for continuous monitoring of temperatures, pressures, etc., and periodic control test functions.
- (3) Manual override permits test and checkout functions to be reinstated for contingency.
- (4) For long term maintenance during which a second OTV is to be serviced, the manipulator may relocate OTV to an alternate station on the opposite side of the FSF where a single maintenance electrical umbilical is provided. Alternate umbilical need not be a swing arm.

SERVICING ACTIVITY DATA

SCENARIO: OTV/SOC Servicing

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ACTIVITY: 12.0 Checkout OTV
13.0 Resupply Consumables

DESCRIPTION: Once a payload is made ready for a mission and it is to be mated to the OTV, the OTV will be fully checked-out and re-supplied with consumables. The activity requires the activation of an automatic checkout sequence and refueling through the umbilical. Sufficient non-cryogenic consumables will be stored on the SOC to refuel the OTV. Cryogenic consumables will be supplied from tankage on board the orbiter payload bay.

SUPPORT EQUIPMENT:

- (1) ACE
- (2) Umbilical System
- (3) Consumables

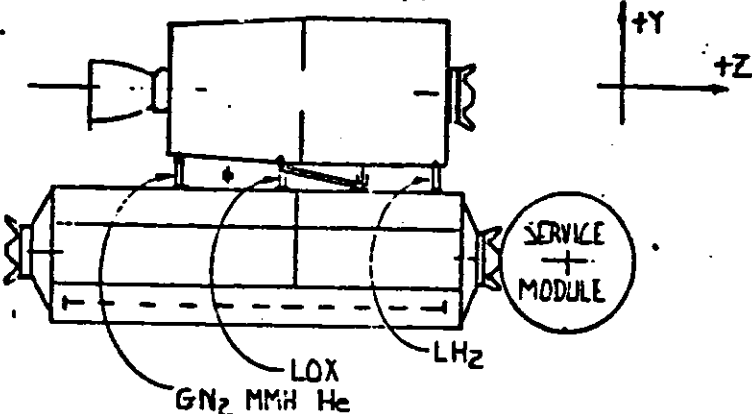
SOC PROVISIONS:

- (1) ACE
- (2) Umbilical System
- (3) Consumables and Storage Containers.

OTV PROVISIONS: Compatibility with ACE and Umbilical System.

ORBITER PROVISIONS: None.

SERVICING ACTIVITY DATA

FUNCTION ITEM	OTV/SOC Servicing 12.0 Checkout OTV & 13.0 Resupply Consumables	ATTACHMENT	
METHOD	PAGE		
SUBJECT Selected Method			
<p style="text-align: center;">ORIGINAL PAGE IS OF POOR QUALITY</p> 			
<p>OTV remains at checkout station with electric umbilical connected for power, control and data.</p> <p>Test and checkout all operating functions including shut-off and isolation valve operations.</p> <p>Engage and connect all three fluid umbilicals.</p> <p>Using the manifold, valves, and pumping system of the PSF:</p> <ul style="list-style-type: none"> Refill OTV tanks with He, MMH & GN₂ Refill OTV tanks with LOX Refill OTV tanks with LH₂ <p>Retract fluid umbilicals.</p>			

SERVICING ACTIVITY DATA

SCENARIO: OTV/SOC Servicing

ACTIVITY: Mate OTV and Payload

DESCRIPTION: The mating operation of the OTV to its payload is dependent on the type of payload. In this case, a COMSAT is the payload which requires the repositioning of the OTV to provide clearance for all the COMSAT appendages and the grappling and separation of the COMSAT from its interface at the end of SM-2 and translating it to an eventual mating with the OTV.

SUPPORT EQUIPMENT:

- (1) Retractable PIDA Head on Translation Rail.
- (2) Rotatable PIDA Head on Translation Rail.
- (3) Umbilical Compatible With Repositioned OTV.
- (4) Manipulator.

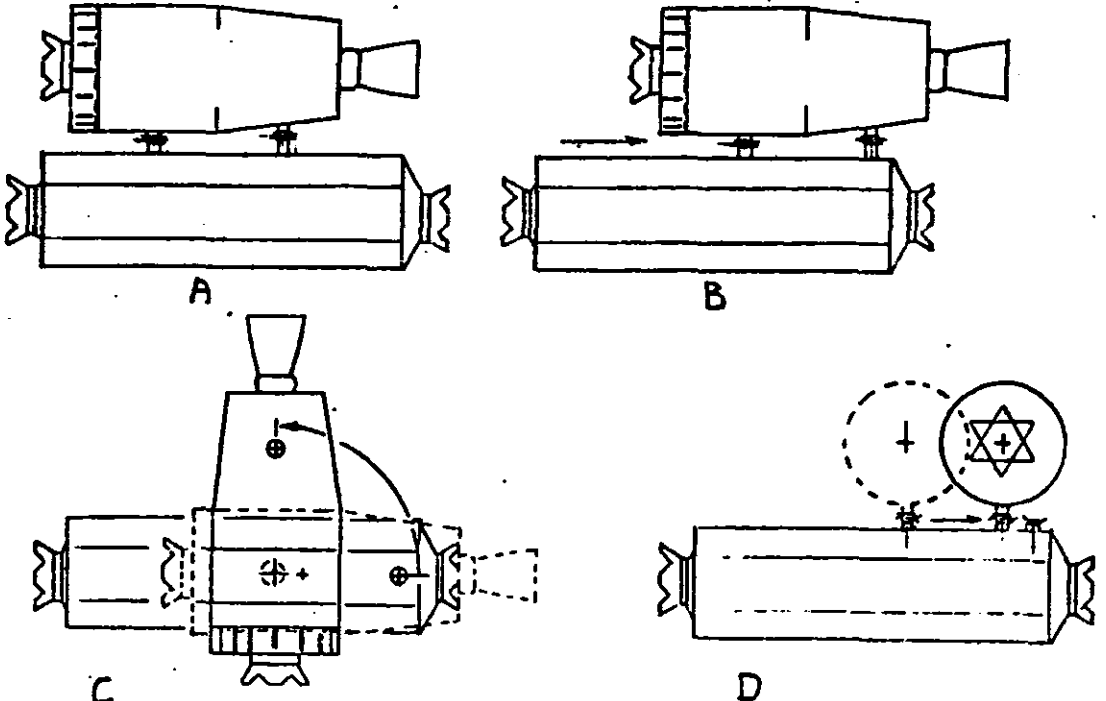
SOC PROVISIONS:

- (1) Retractable PIDA Head on Translation Rail.
- (2) Rotatable PIDA Head on Translation Rail.
- (3) Umbilical Compatible With Repositioned OTV.
- (4) Manipulator.

OTV PROVISIONS: Adapter to accept payload.

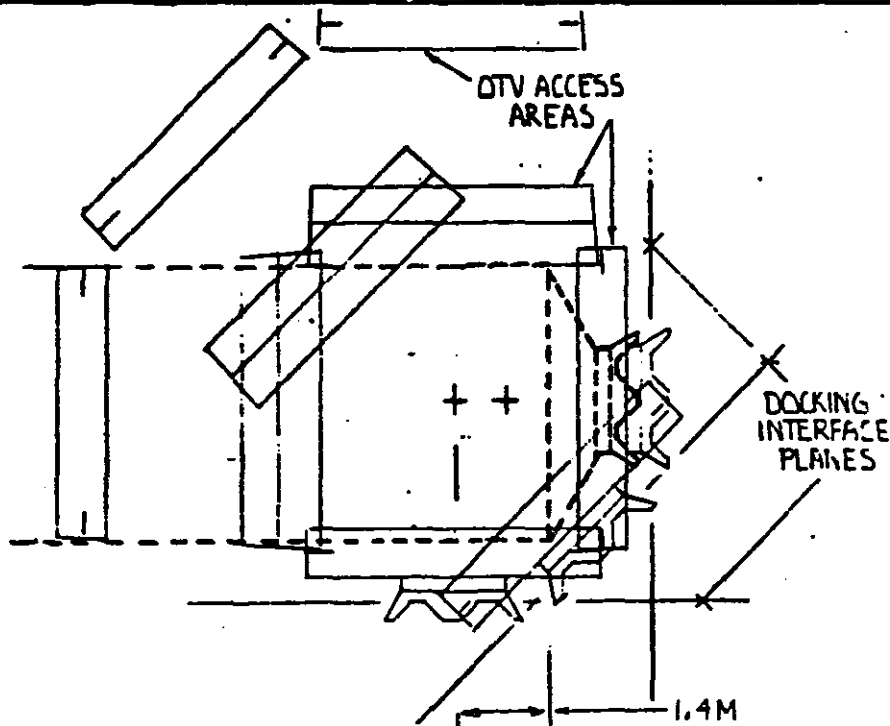
ORBITER PROVISIONS: None.

SERVICING ACTIVITY DATA

FUNCTION ITEM	OTV/SOC Servicing 14.0 Mate OTV & Payload	ATTACHMENT	
METHOD		PAGE	
SUBJECT	Selected Method		
			
<p>(A) OTV is at checkout station with electrical umbilical connected.</p> <p>(B) OTV translated to -Z end of service fixture.</p> <p>(C) Rear PIDA head is unlatched and retracted. Front PIDA head is rotated 90° to position OTV crossways on service fixture.</p> <p>(D) Front PIDA head translates OTV to -Z end of service fixture.</p> <p style="text-align: center;">ORIGINAL DESIGN OF POOR QUALITY</p>			

SERVICING ACTIVITY DATA

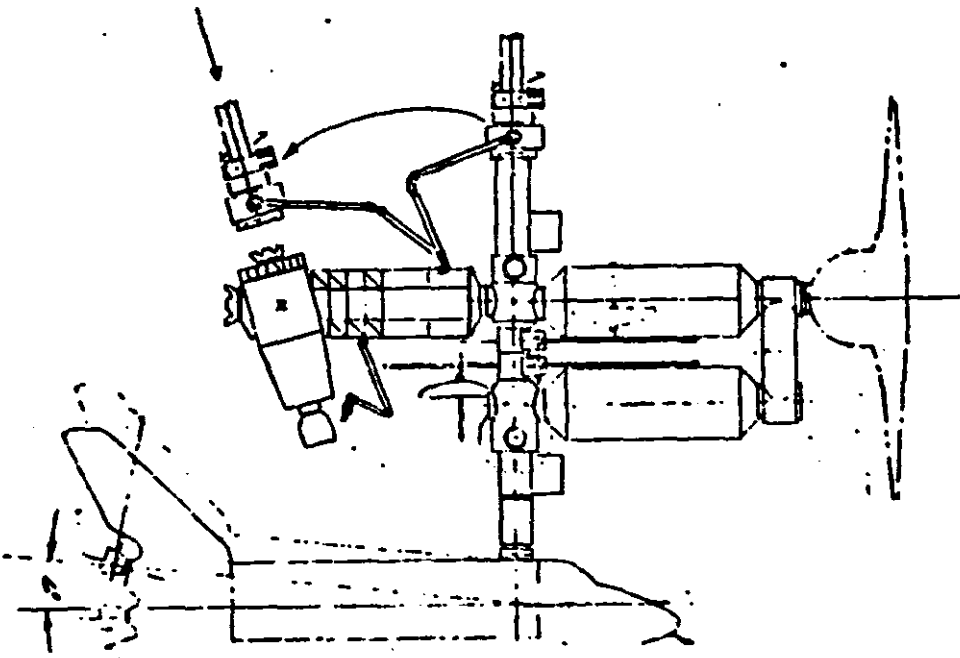
FUNCTION ITEM	OTV/SOC Servicing 14.0 Mate OTV & Payload	ATTACHMENT	
		PAGE	
METHOD			
SUBJECT		Selected Method (Cont'd)	



With front PIDA head at no more than 1.4m from -Z end of service fixture, OTV may be rotated further to 135° or 180° with the plane of the OTV-payload docking interface clearing the outline of the service fixture. Umbilicals and service access areas of the OTV are indicated. OTV is rotated to an angle compatible with the payload to be docked.

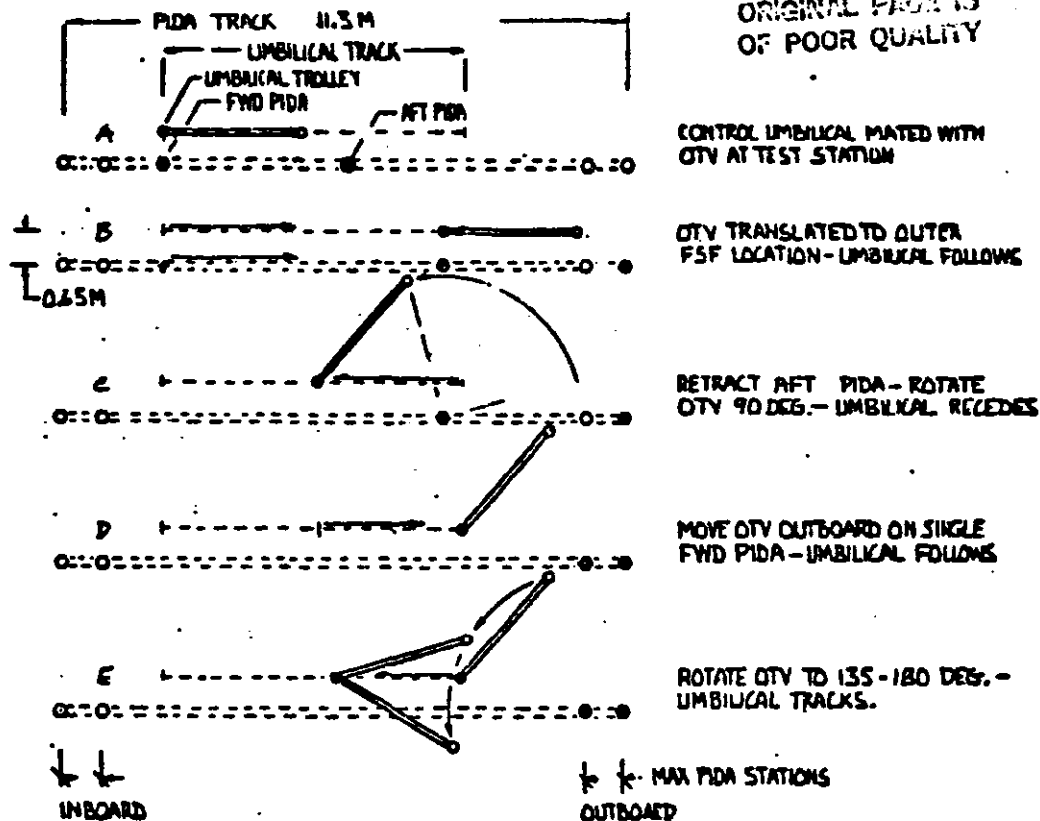
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SERVICING ACTIVITY DATA

FUNCTION ITEM	OTV/SOC Servicing 14.0 Mate OTV & Payload	ATTACHMENT	
METHOD		PAGE	
SUBJECT Selected Concept (Cont'd)			
			
<p>When OTV is in position the service fixture manipulator system picks up the payload from the SOC and transports it to the OTV location making a connection with the OTV docking port.</p> <p>The OTV continues to be under direct umbilical control from the SOC control station for interface verification and payload checkout.</p> <p style="text-align: center;">ORIGINAL PAGE IS OF POOR QUALITY.</p>			

SERVICING ACTIVITY DATA

FUNCTION ITEM	OTV/SOC Servicing 14.0 Mate OTV & Payload	ATTACHMENT	
		PAGE	
METHOD			
SUBJECT	SOC Support Operations		



- (1) Swing Arm Umbilical (5.0.)
- (2) Umbilical Track Next to PIDA Rails (5.0)

Once connected to the OTV, the electric umbilical swing arm can be free to follow the OTV passively along the service fixture.

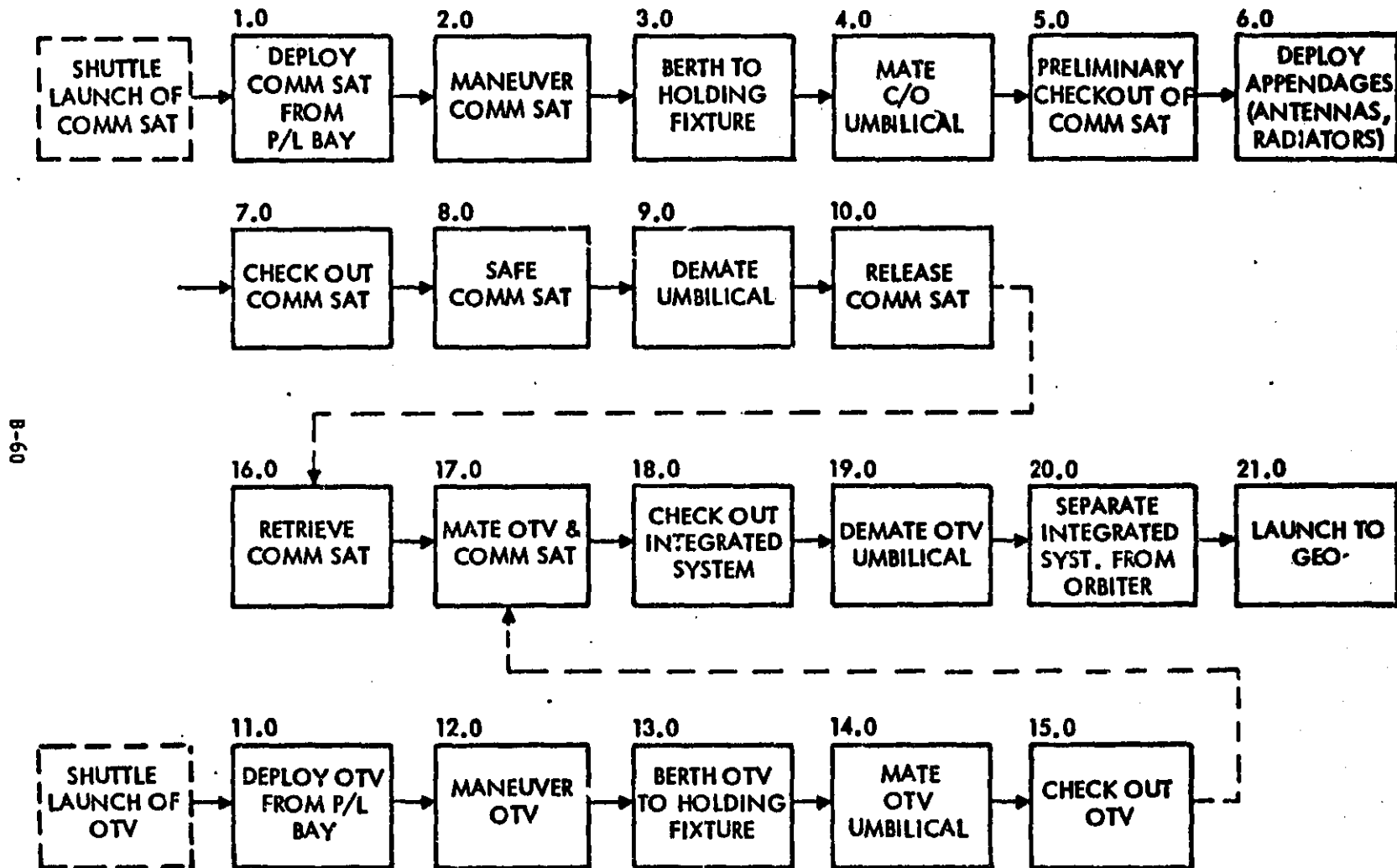
In B&D above, the swing arm follows the OTV in translation.

In C&E above, the rotational motion of the OTV forces the swing arm along its track.

Nominal tracking forces may be programmed into the swing arm carrier to assist in tracking.

The SOC interface for control and monitoring is maintained at the OTV from Safe and Checkout (6.0) through Reposition and Mating (13.0) without disconnect.

COMM SAT -- ORBITER SERVICING



SERVICING ACTIVITY DATA

SCENARIO: COMMSAT - Orbiter Servicing .

ACTIVITY: Initial Delivery

DESCRIPTION: The COMMSAT is delivered into orbit with the necessary ASE as indicated on the next page. Subsequently, COMMSAT is deployed and checked out, the OTV is launched, deployed and checked out and finally OTV and COMMSAT are mated, checked out and separated from the orbiter. The sequence of these operational events are described on the following pages.

SUPPORT EQUIPMENT:

- (1) Control and Monitor Station
- (2) PIDA
- (3) HPA
- (4) Umbilical System

COMMSAT PROVISIONS:

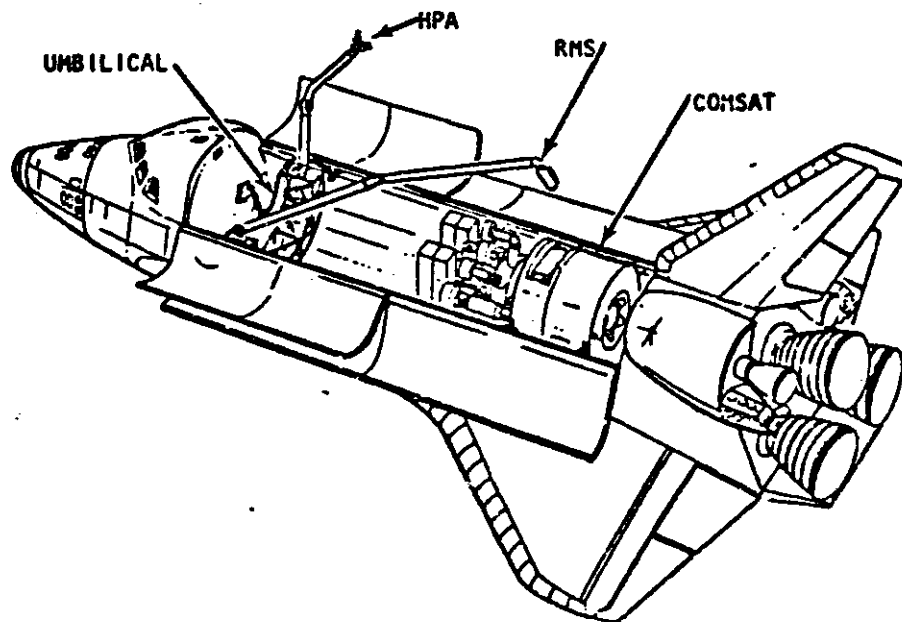
- (1) PIDA Head
- (2) Grapple Fixture
- (3) HPA Interface
- (4) COMMSAT/Orbiter System Checkout Interface
- (5) Appendages With Remote Release Deploy & Latch System
- (6) Manual Override Provisions for all Mechanisms
- (7) Safing System
- (8) COMMSAT/OTV Structural & Functional Interfaces
- (9) Accessible Component Design
- (10) Communication & Data Links With Orbiter Ground OCC

ORBITER PROVISIONS:

- (1) PIDA
- (2) HPA
- (3) Retractable Umbilical System
- (4) OTV Compatible With COMMSAT
- (5) Open Cherry Picker & MMU
- (6) COMMSAT Control & Monitor Station
- (7) Communication & Data Links With COMMSAT & Its Ground OCC
- (8) System Continuity Orbiter/OTV/COMSAT

SERVICING ACTIVITY DATA

FUNCTION ITEM	COMMSAT/Orbiter Servicing Delivery & Initial Check	ATTACHMENT	
METHOD	From Orbiter	PAGE	
SUBJECT	Operation Identification		

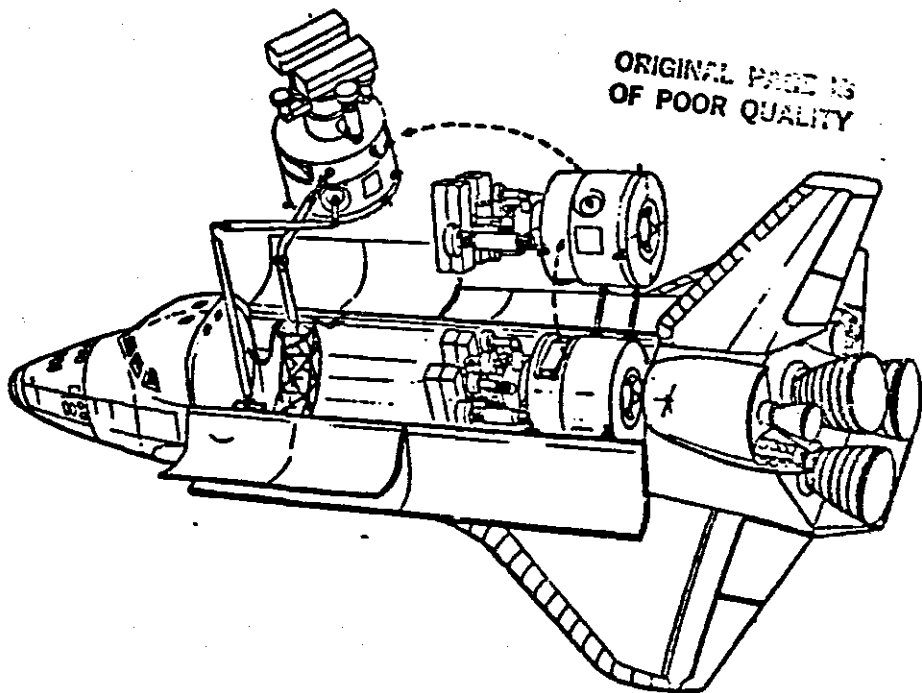


SCENARIO: Deliver satellite (COMSAT) to LEO, deploy appendages and place in orbit. Revisit delivering OTV, assemble and activate for transfer to GEO.

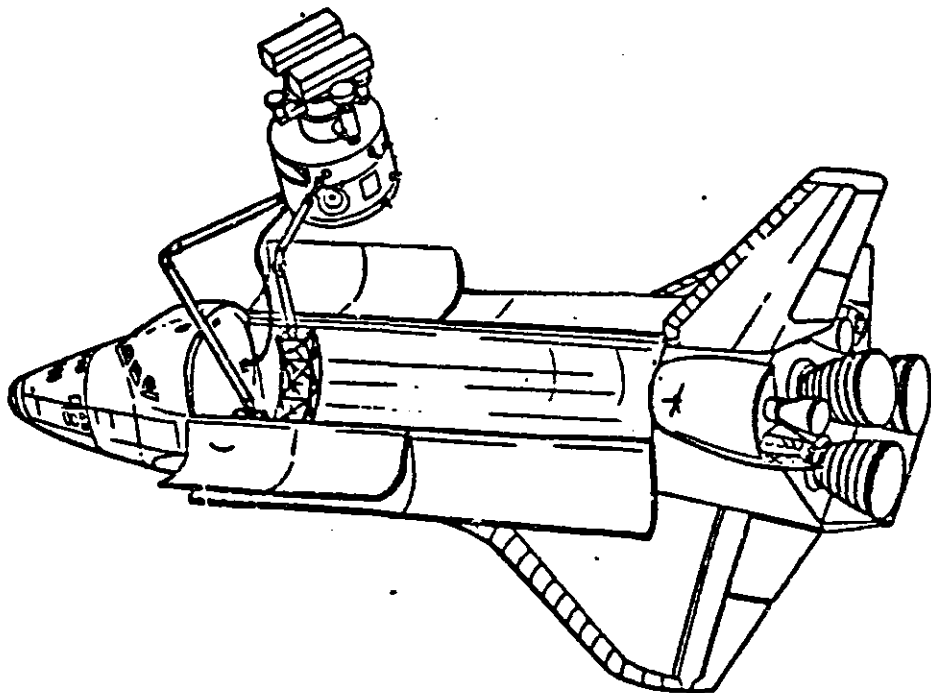
- o Open Payload Doors
- o Deploy RMS & Check Functions
- o Deploy HPA & Check Functions

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SERVICING ACTIVITY DATA

FUNCTION ITEM	COMMSAT/Orbiter Servicing 1.0 thru 3.0 Deploy & Berth COMMSAT	ATTACHMENT	
METHOD	From Orbiter	PAGE	
SUBJECT	Method Description		
			
<p>(1) PIDA devices activated deploying satellite.</p> <p>(2) RMS removes satellite from PIDA devices.</p> <p>(3) RMS berths satellite on HPA.</p>			

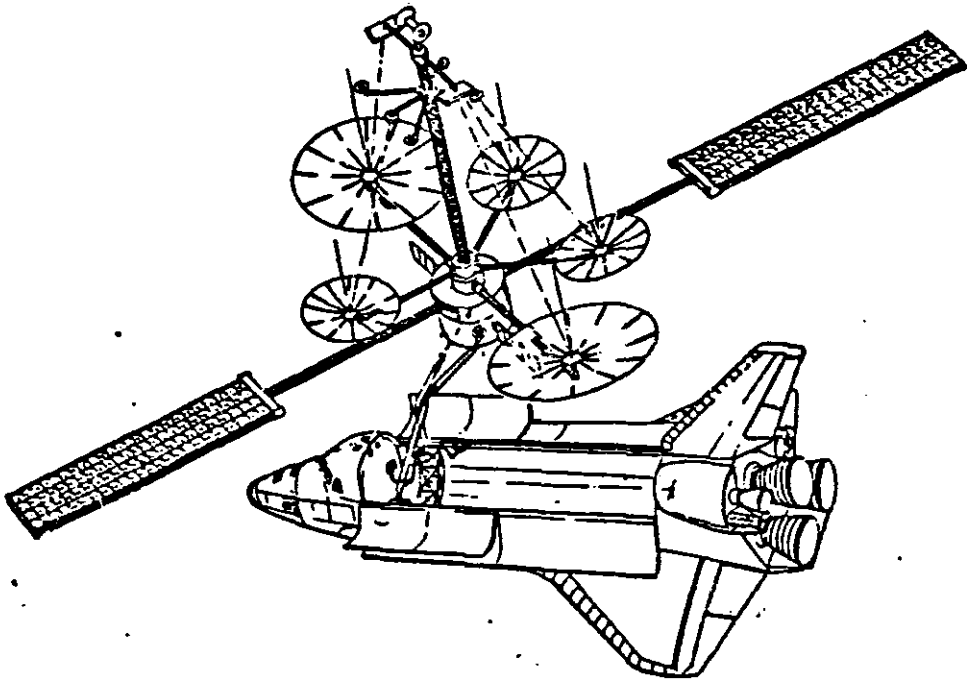
SERVICING ACTIVITY DATA

FUNCTION ITEM	COMSAT/Orbiter Servicing 4.0 Mate Umbilical & 5.0 Checkout COMSAT	ATTACHMENT		
METHOD	From Orbiter	PAGE		
SUBJECT	Method Description			
				
<p>(1) RMS locks onto umbilical.</p> <p>(2) RMS connects umbilical to COMSAT.</p> <p>(3) Checkout of COMSAT functions.</p> <p style="text-align: center;">ORIGINAL PHOTO OF POOR QUALITY</p>				

SERVICING ACTIVITY DATA

FUNCTION ITEM	COMSAT/Orbiter Servicing 6.0 Deploy COMSAT Appendages	ATTACHMENT		
METHOD	From Orbiter	PAGE		
SUBJECT	Method Description			
<p>Deploy appendages in sequence shown.</p> <ul style="list-style-type: none"> (1) Solar arrays and radiators deployed. (2) Antenna booms and horn mast extended. (3) Antennas and horn assembly deployed. 				
<p>ORIGINAL FIGURES OF POOR QUALITY</p>				

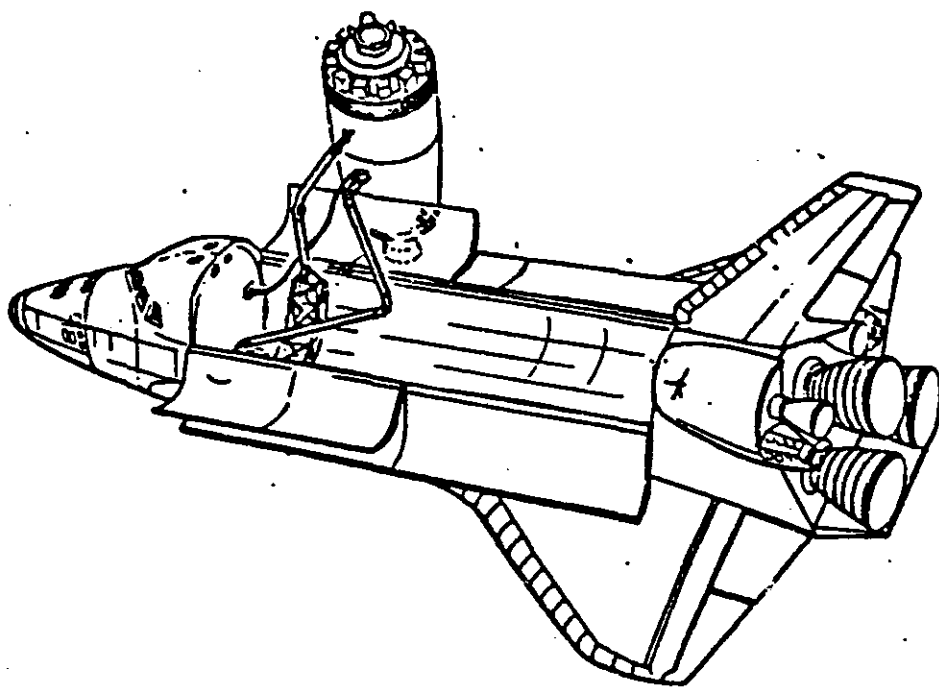
SERVICING ACTIVITY DATA

FUNCTION ITEM	COMMSAT/Orbiter Servicing 7.0 thru 10.0 Checkout & Release COMMSAT From Orbiter	ATTACHMENT	
METHOD		PAGE	
SUBJECT	Method Description		
			
<p>(1) Complete checkout of COMMSAT systems.</p> <p>(2) Safe COMMSAT via RF.</p> <p>(3) PMS disconnects and stows umbilical.</p> <p>(4) RMS removes COMMSAT from HPA.</p> <p>(5) COMMSAT released to orbit.</p> <p>(6) Orbiter returns to earth.</p> <p style="text-align: right;">ORIGINAL FILED IN OF POOR QUALITY</p>			

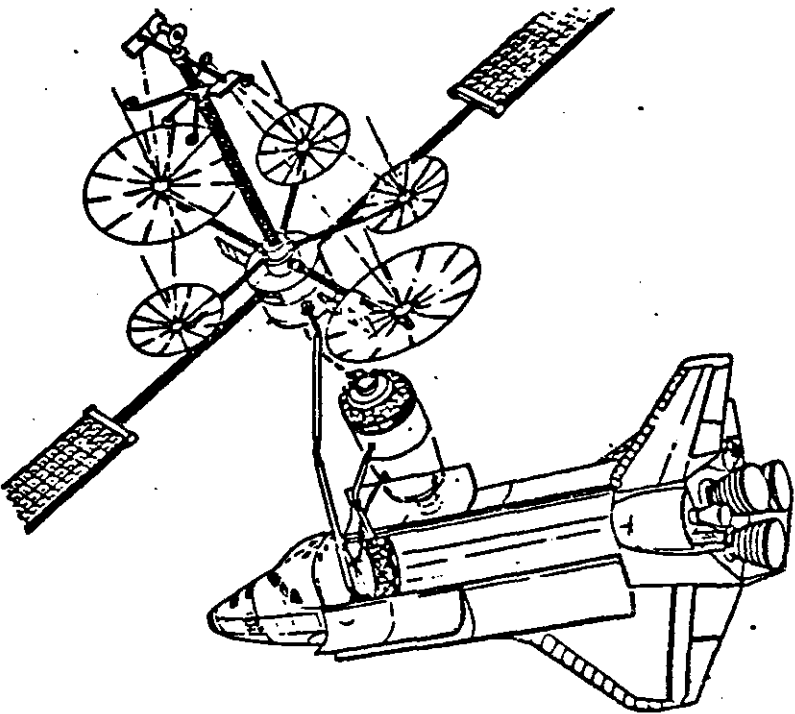
SERVICING ACTIVITY DATA

FUNCTION ITEM	COMSAT/Orbiter Servicing 11.0 thru 13.0 Deploy & Mate OTV	ATTACHMENT		
METHOD	From Orbiter	PAGE		
SUBJECT	Method Description			
<p>Orbiter returns to COMSAT's orbit.</p> <ol style="list-style-type: none"> (1) Open payload bay doors. (2) Deploy RMS and check functions. (3) Deploy HPA and check functions. (4) RMS locks on to OTV in bay. (5) OTV removed and translated to HPA. (6) RMS berths OTV to HPA. 				
<p>ORIGINAL HERE IS OF POOR QUALITY</p>				

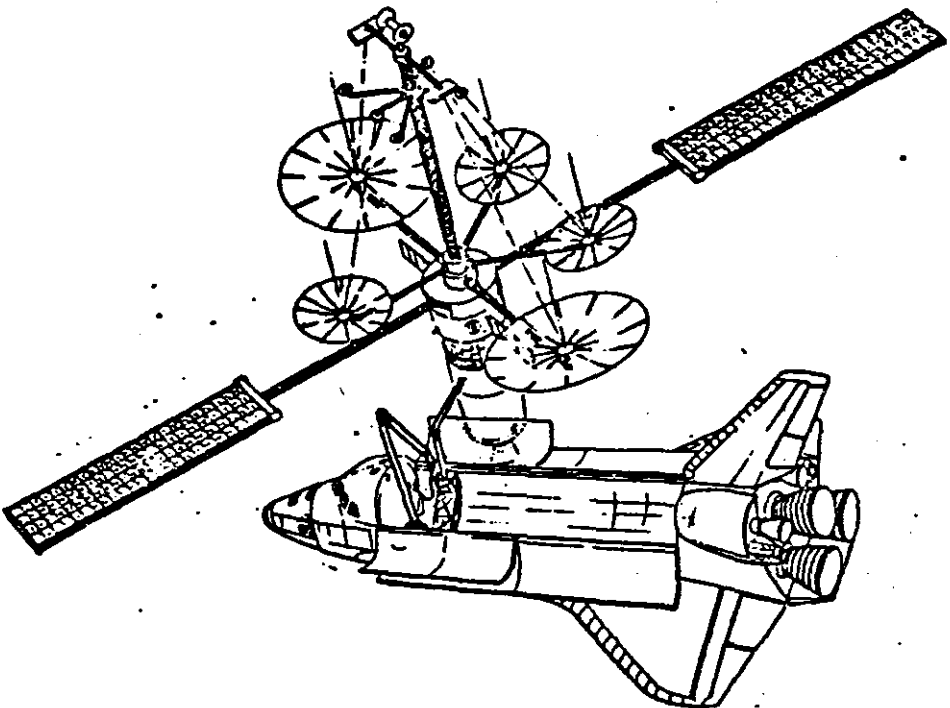
SERVICING ACTIVITY DATA

FUNCTION ITEM	COMSAT/Orbiter Servicing 14.0 Mate Umbilical & 15.0 Checkout OTV	ATTACHMENT	
METHOD	From Orbiter	PAGE	
SUBJECT Method Description			
			
<p>(1) RMS pickup umbilical and connects same to OTV.</p> <p>(2) All OTV systems checked out.</p> <p style="text-align: center;">ORIGINAL PAGE 10 OF POOR QUALITY</p>			

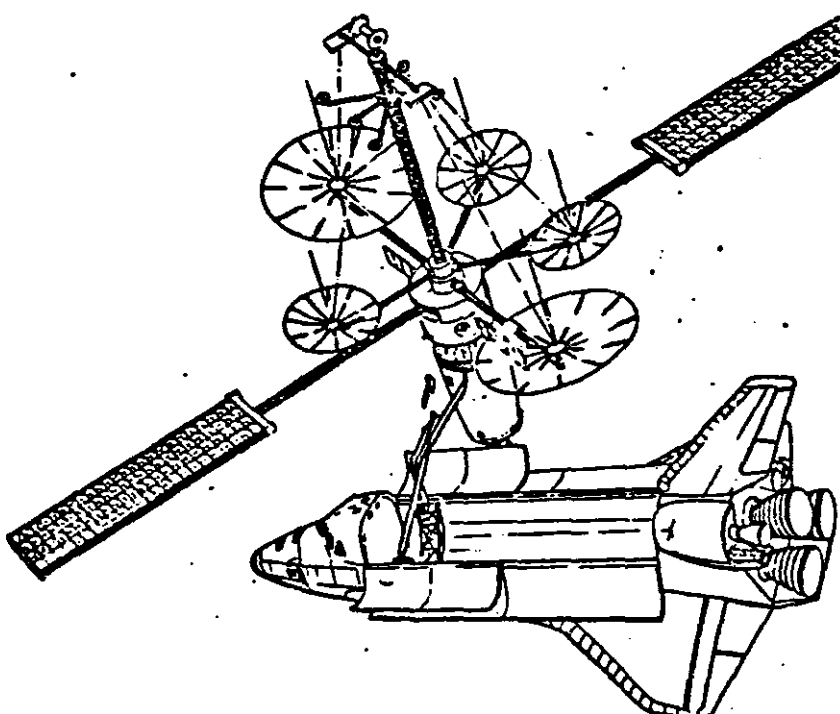
SERVICING ACTIVITY DATA

FUNCTION ITEM	COMMSAT/Orbiter Servicing 16.0 Retrieve COMMSAT & 17.0 Mate to OTV.	ATTACHMENT	
METHOD	From Orbiter	PAGE	
SUBJECT	Method Description		
			
<p data-bbox="315 1230 733 1304">(1) RMS retrieves COMMSAT. (2) RMS mates COMMSAT to OTV.</p> <p data-bbox="712 1556 964 1629">ORIGINAL PAGE IS OF POOR QUALITY</p>			

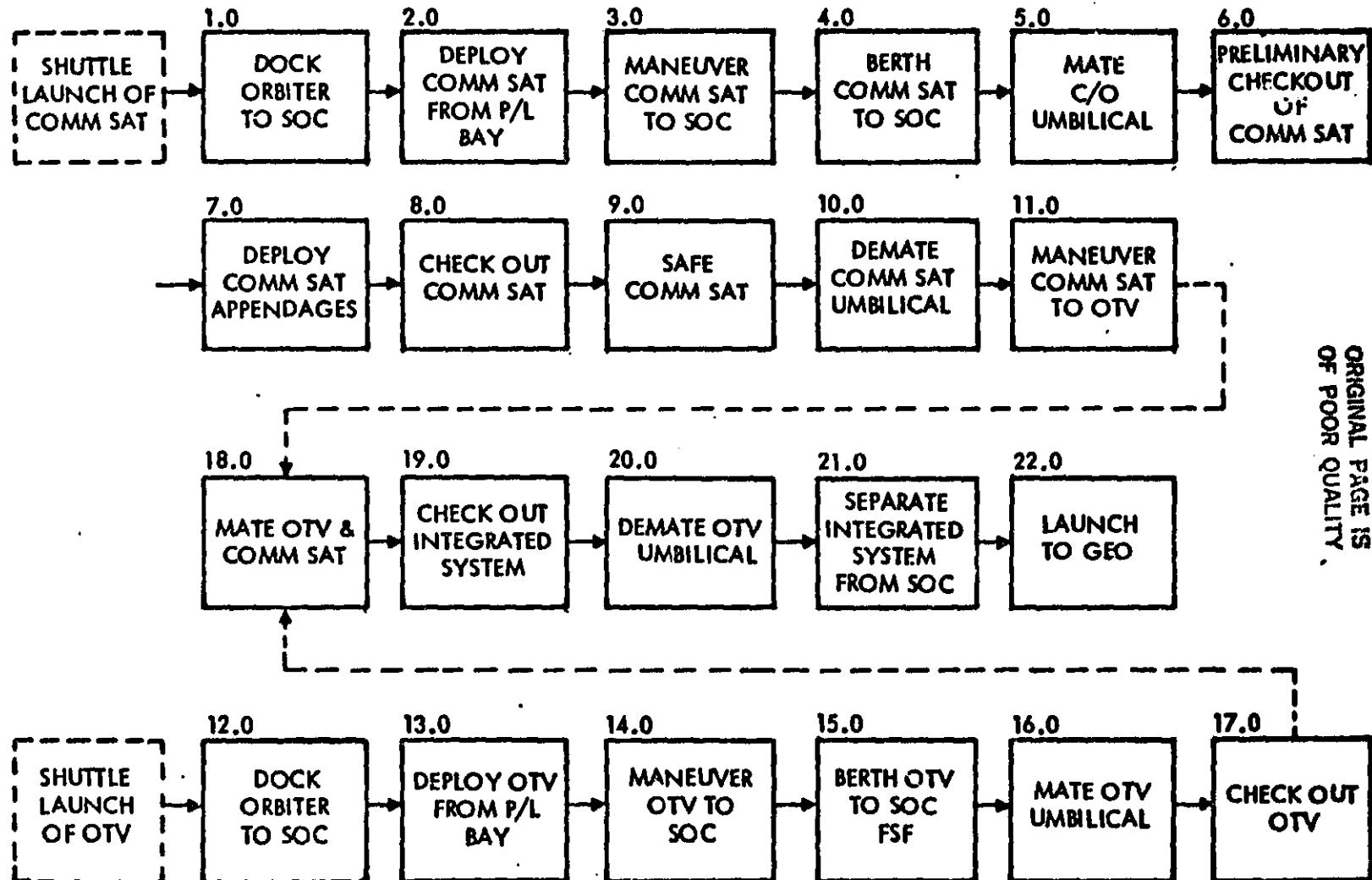
SERVICING ACTIVITY DATA

FUNCTION ITEM	COMSAT/Orbiter Servicing 18.0 C/O & 19.0 Demate Umbilical	ATTACHMENT	
METHOD	From Orbiter	PAGE	
SUBJECT	Method Description		
			
<p>(1) Checkout integrated systems.</p> <p>(2) RMS demates umbilical and stows same.</p>			
<p>ORIGINAL PAGE IS OF POOR QUALITY</p>			

SERVICING ACTIVITY DATA

FUNCTION ITEM	COMSAT/Orbiter Servicing 20.0 Separate & 21.0 Launch Sat. Assy.	ATTACHMENT	
METHOD	From Orbiter	PAGE	
SUBJECT	Method Description		
			
<p>(1) RMS removes OTV from HPA and replaces satellite assembly in orbit.</p> <p>(2) OTV activated launching satellite to GEO. .</p>			
<p>ORIGINAL PAGE NO OF POOR QUALITY</p>			

COMM SAT -- SOC SERVICING



ORIGINAL PAGE IS
OF POOR QUALITY

B-72



SERVICING ACTIVITY DATA

SCENARIO: COMMSAT/SOC Servicing

ACTIVITY: Initial Delivery

DESCRIPTION: Servicing the COMMSAT on the SOC involves the delivery, deployment and checkout of the COMMSAT and its orbit transfer vehicle (OTV), final mating of the two components and eventual launch to the COMMSAT operational orbit (GEO). For this particular scenario, initial launch of the OTV is assumed. Consequently, the OTV servicing portion involves checkout and fuel loading operations only.

SUPPORT EQUIPMENT:

Sufficient ASE is required to accommodate the scenario as listed below.

SOC PROVISIONS:

- (1) Manipulator With Standard End Effector.
- (2) CCTV Camera on Manipulator.
- (3) Active Berthing Port With Alignment Monitoring System.
- (4) Retractable Umbilical System.
- (5) OTV Compatible With COMMSAT.
- (6) System Continuity SOC/OTV/COMMSAT.
- (7) Open Cherry Picker & MMU.
- (8) COMMSAT Control & Monitor Station.
- (9) Communication & Data Link With COMMSAT & Its OCC.

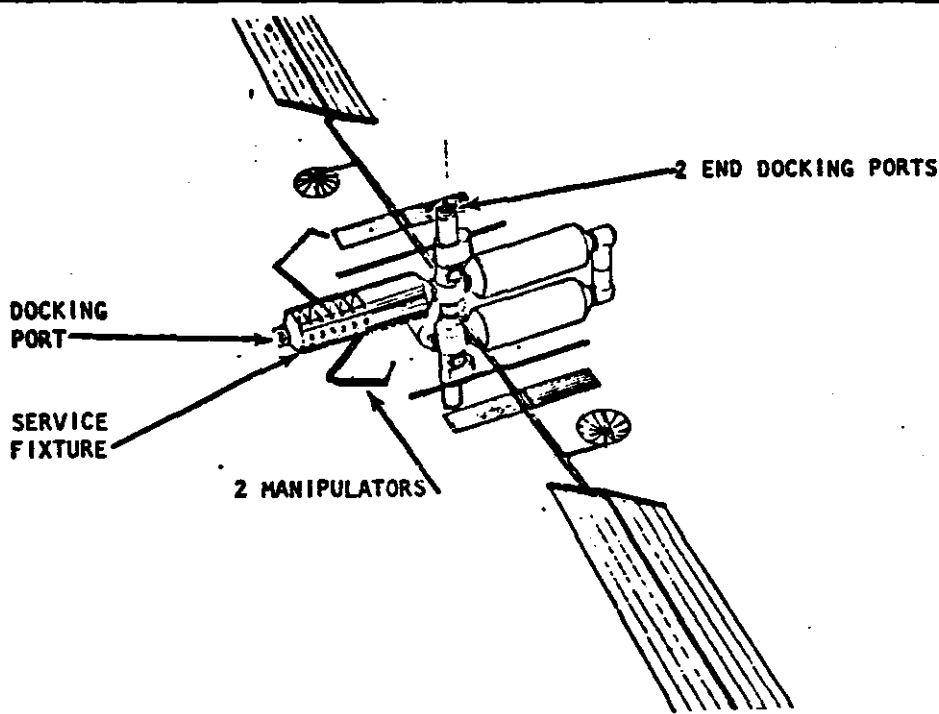
COMMSAT PROVISIONS:

- (1) PIDA Head
- (2) Grapple Fixture.
- (3) Berthing Port With Alignment Target.
- (4) COMMSAT/SOC System C/O Interface.
- (5) Appendages With Remote Release, Deploy, & Latch System.
- (6) Safing System.
- (7) COMMSAT/OTV Structural & Functional Interfaces.
- (8) Accessible Component Design.
- (9) Communication & Data Links With SOC & Ground OCC.
- (10) Manual Override Provisions for all Mechanisms.

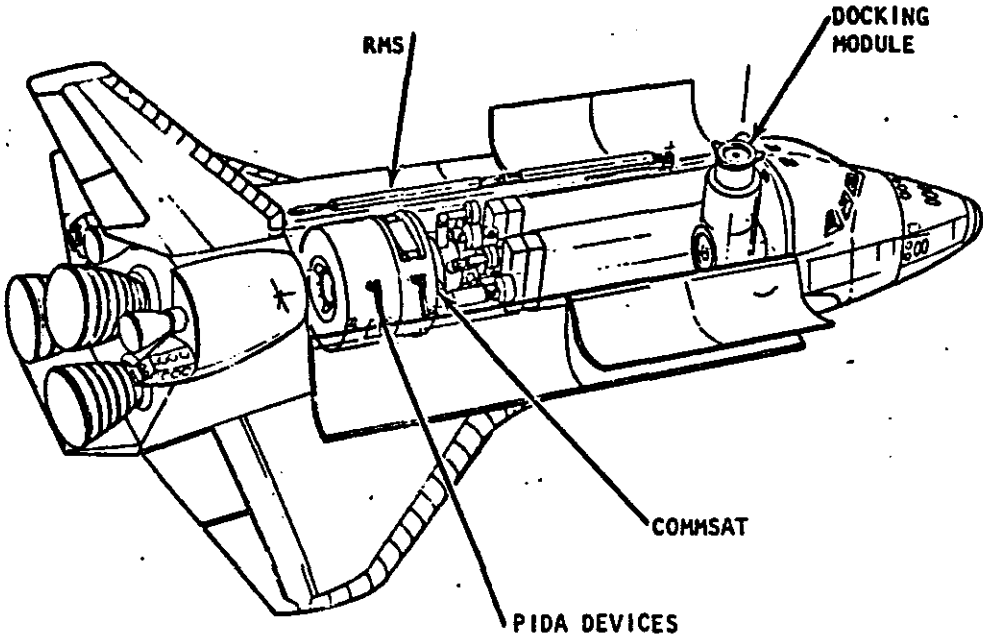
ORBITER PROVISIONS:

PIDA

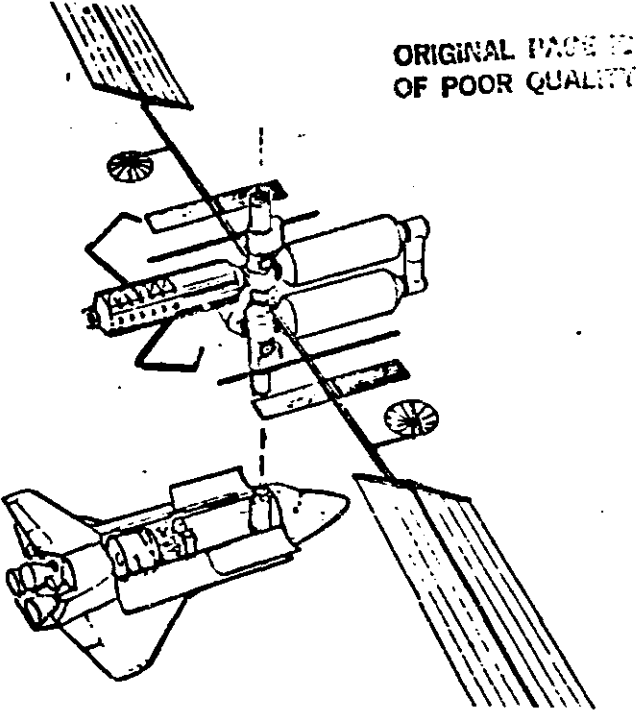
SERVICING ACTIVITY DATA

FUNCTION ITEM	COMMSAT/SOC Servicing Assembly & Servicing	ATTACHMENT	
METHOD	At Space Operations Center	PAGE	
SUBJECT Scenario			
			
<p>SOC is the hard back to which the COMMSAT is held for checkout, appendage deployment and LEO station awaiting OTV delivery.</p> <p>The OTV is delivered and berthed to the SOC service fixture, which is used as an assembly station for the two components.</p> <p>Transfer of vehicles and mating operation is accomplished with the aid of the service fixture manipulator.</p> <p style="text-align: center;">ORIGINAL PAGE IS OF POOR QUALITY</p>			

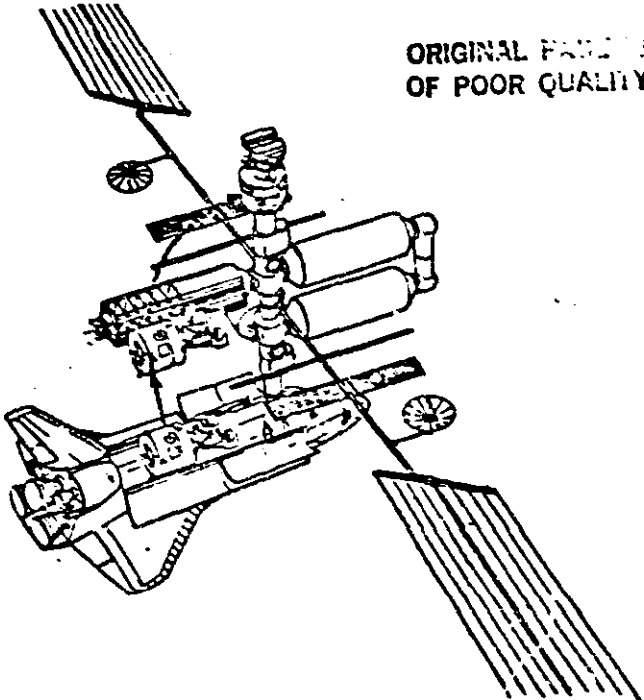
SERVICING ACTIVITY DATA

FUNCTION ITEM	COMMSAT/SOC Servicing Delivery & Initial Check	ATTACHMENT	
METHOD	From Orbiter	PAGE	
SUBJECT	Method Description		
 <p>The diagram illustrates a spacecraft in profile, viewed from the side. It features a large payload bay with various equipment. Labels with leader lines point to specific components: 'RMS' (Remote Manipulator System) is located near the front of the bay; 'DOCKING MODULE' is at the rear of the bay; 'COMMSAT' (Communications Satellite) is positioned in the middle of the bay; and 'PIDA DEVICES' (Payload Instrument Deployment Devices) are shown as a series of rotating mechanisms along the length of the bay.</p>			
<p>(1) Open Payload Bay Doors.</p> <p>(2) Deploy RMS and checkout functions.</p> <p>(3) Extend docking module and checkout systems.</p> <p>(4) Activate PIDA devices revolving COMMSAT out of payload bay.</p> <p style="text-align: center;">ORIGINAL PAGE IS OF POOR QUALITY</p>			

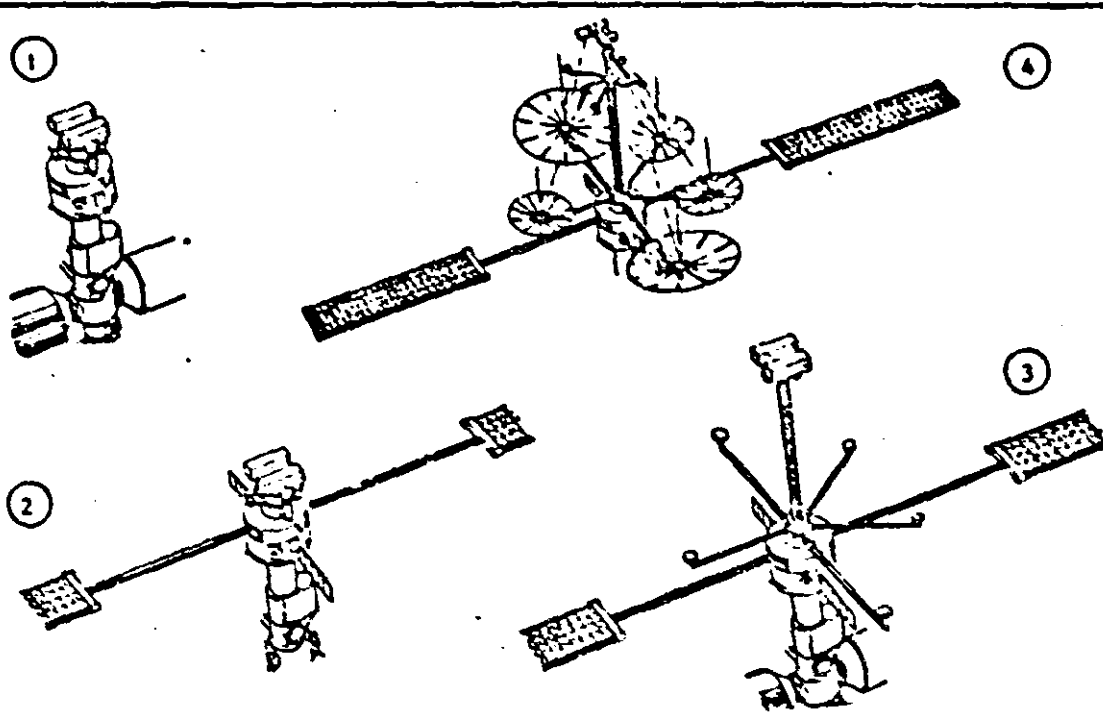
SERVICING ACTIVITY DATA

FUNCTION ITEM	COMSAT/SOC Servicing 1.0 Dock to SOC	ATTACHMENT	
METHOD	By Orbiter	PAGE	
SUBJECT Method Description			
			
<p>(1) Orbiter aligns with SOC and performs pre-docking activity.</p> <p>(2) Orbiter docks to SOC's end docking port.</p> <p>(3) Latches secured and interface systems checkout.</p>			

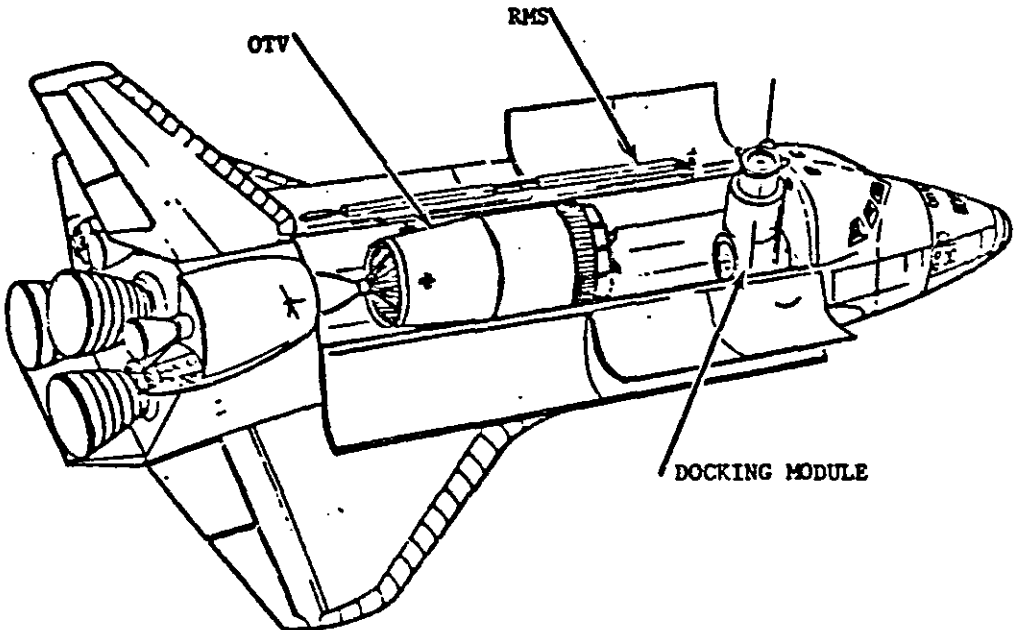
SERVICING ACTIVITY DATA

FUNCTION ITEM	COMMSAT/SOC Servicing 2.0 thru 5.0 Manuever & Mate to SOC	ATTACHMENT	
METHOD	From Orbiter to SOC	PAGE	
SUBJECT Method Description			
 <p>ORIGINAL PAGE IS OF POOR QUALITY</p>			
<ol style="list-style-type: none"> (1) RMS Activated locks on to COMMSAT. (2) FIDA devices release COMMSAT. (3) RMS translate COMMSAT towards service fixture. (4) RMS stabilizes COMMSAT while service fixture manipulator is activated and locks onto same. (5) RMS releases COMMSAT and returns to orbiter. (6) Manipulator transfers COMMSAT to end docking port. (7) Manipulator performs berthing operation. (8) Systems mated through docking port interface. 			

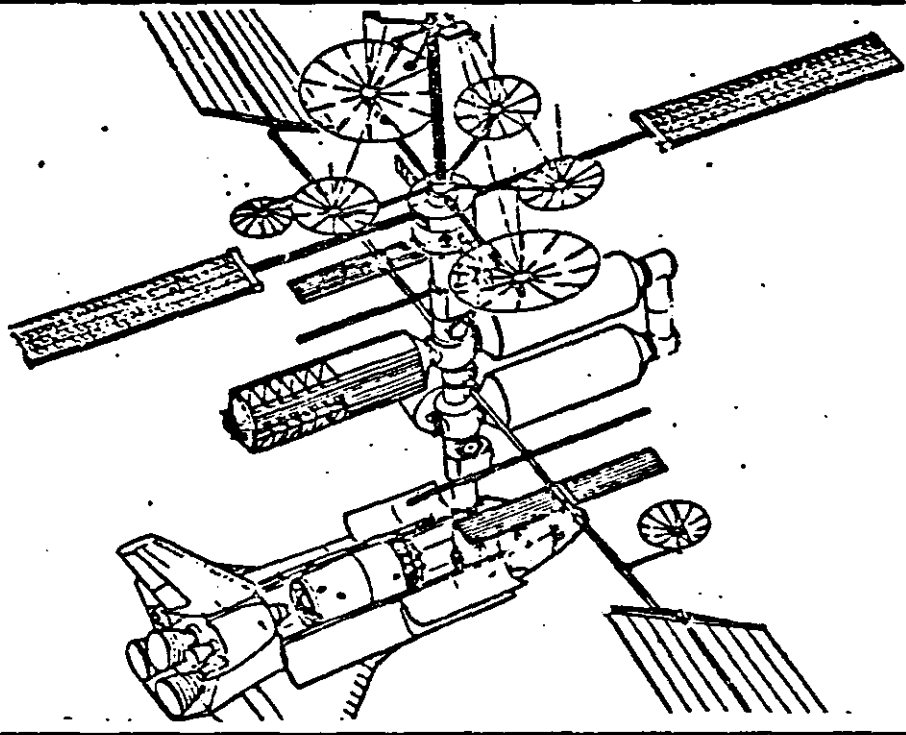
SERVICING ACTIVITY DATA

FUNCTION	COMMSAT/SOC Servicing	ATTACHMENT	
ITEM	6.0 C/O & 7.0 Deploy Appendages		
METHOD	By SOC Control	PAGE	
SUBJECT Method Description			
 <p>The diagrams illustrate the deployment sequence of a satellite's appendages. Diagram (1) shows the satellite in a compact state. Diagram (2) shows the solar arrays and radiators deployed. Diagram (3) shows the antenna booms and horn mast extended. Diagram (4) shows the antennas and horn assembly deployed.</p>			
<p>(1) Preliminary checkout of COMMSAT systems by SOC.</p> <p>(2) Solar arrays and radiators deployed.</p> <p>(3) Antenna booms and horn mast extended.</p> <p>(4) Antennas and horn assembly deployed.</p>			
<p>ORIGINAL PAGE IS OF POOR QUALITY</p>			

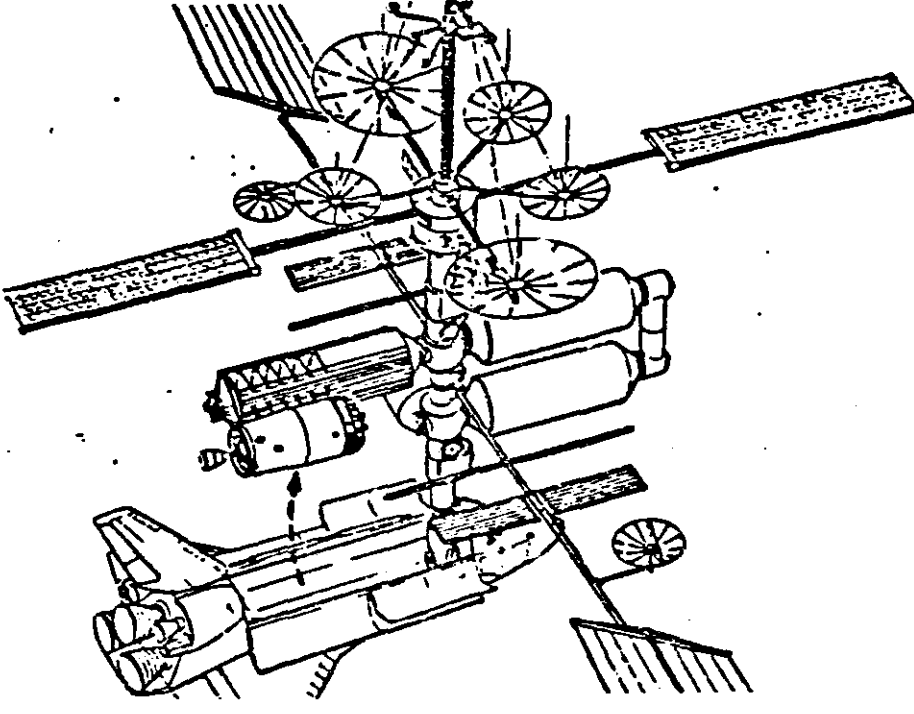
SERVICING ACTIVITY DATA

FUNCTION ITEM	COMSAT/SOC Servicing Delivery & Initial Check OTV	ATTACHMENT	
METHOD	From Orbiter	PAGE	
SUBJECT			
			
<p data-bbox="320 1247 822 1325">(1) Open payload doors. (2) Deploy RMS and check functions.</p> <p data-bbox="766 1667 1017 1738">ORIGINAL PAGE IS OF POOR QUALITY</p>			

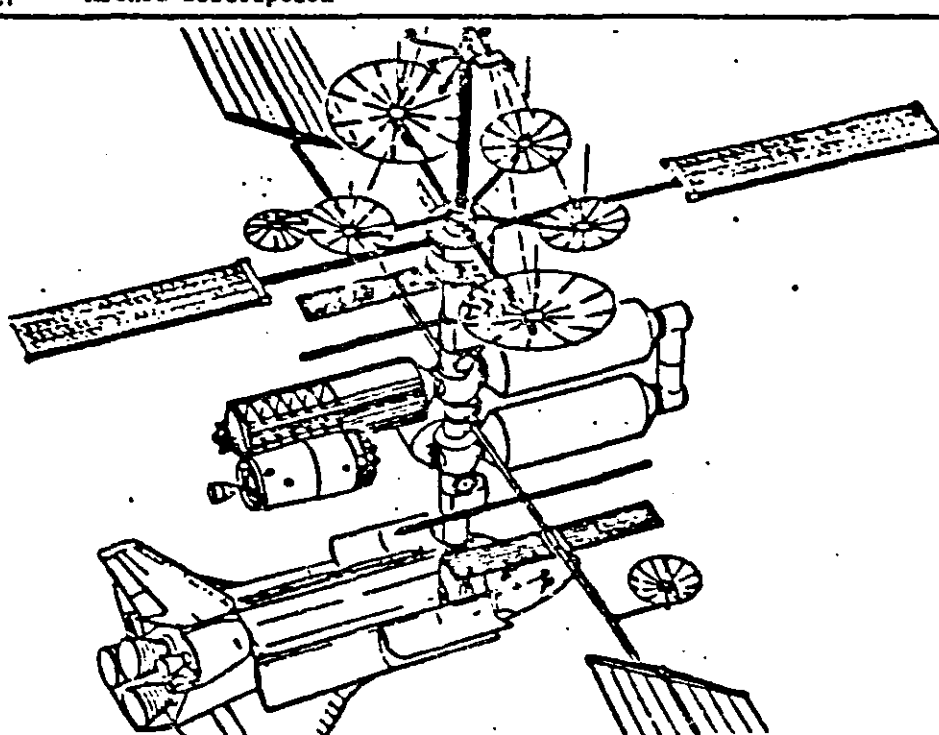
SERVICING ACTIVITY DATA

FUNCTION ITEM	COMSAT/SOC Servicing 12.0 Dock to SOC	ATTACHMENT	
METHOD	By Orbiter	PAGE	
SUBJECT	Method Description		
			
<p>(1) Orbiter aligns with SOC and performs pre-docking activity.</p> <p>(2) Orbiter docks to SOC's end docking port.</p> <p>(3) Latches secured and interface systems checked out.</p> <p style="text-align: center;">ORIGINAL PAGE IS OF POOR QUALITY</p>			

SERVICING ACTIVITY DATA

FUNCTION ITEM	COMSAT/SOC Servicing 13.0 thru 17.0 Berth & Checkout OTV	ATTACHMENT	
METHOD	From Orbiter to SOC	PAGE	
SUBJECT	Method Description		
			
<p>(1) RMS locks onto the OTV removing it from bay.</p> <p>(2) RMS translates OTV towards service fixture.</p> <p>(3) OTV is berthed to track mounted PIDA device. Assistance (or takeover) may be required from the service fixture manipulator for this operation.</p> <p>(4) RMS returns to orbiter.</p> <p>(5) OTV umbilical mated to service fixture interface (EVA operation).</p> <p>(6) OTV systems checked out by SOC control.</p> <p style="text-align: right;">ORIGINAL PAGE IS OF POOR QUALITY</p>			

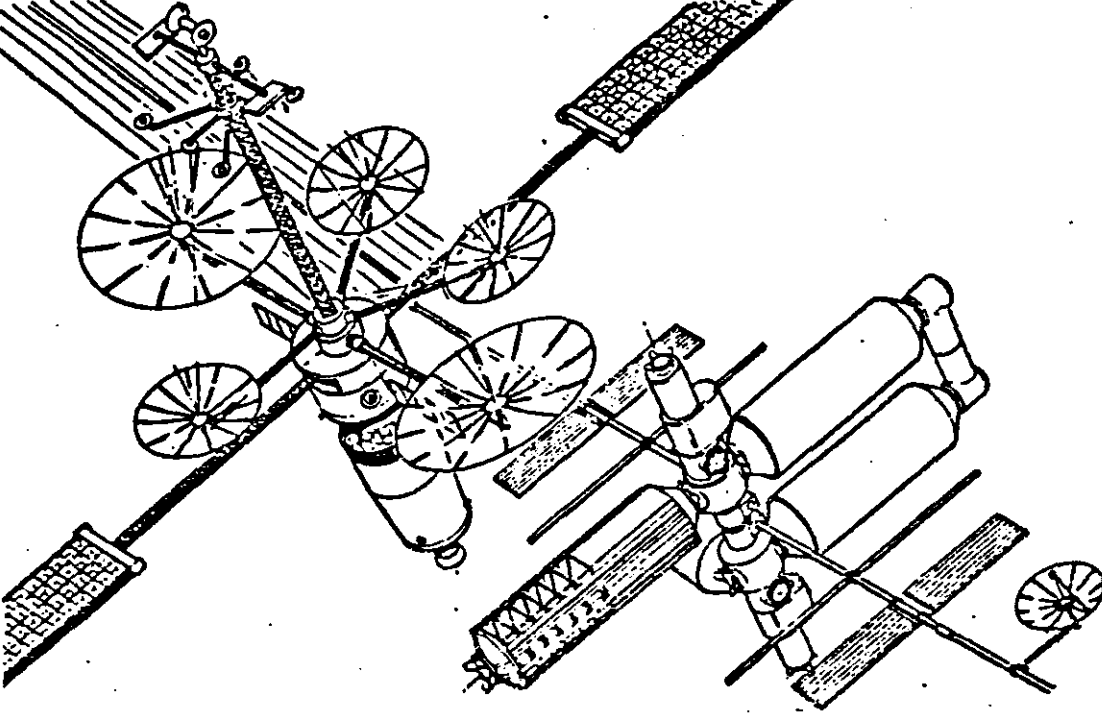
SERVICING ACTIVITY DATA

FUNCTION ITEM	COMMSAT/SOC Servicing 8.0 thru 10.0 C/O & Demate Umbilical	ATTACHMENT	
METHOD	By SOC	PAGE	
SUBJECT	Method Description		
			
<p>(1) Checkout COMMSAT system via SOC control.</p> <p>(2) Safe COMMSAT systems.</p> <p>(3) Close disconnect, etc., at interface ready for separation.</p>			
<p>ORIGINAL PAGE IS OF POOR QUALITY</p>			

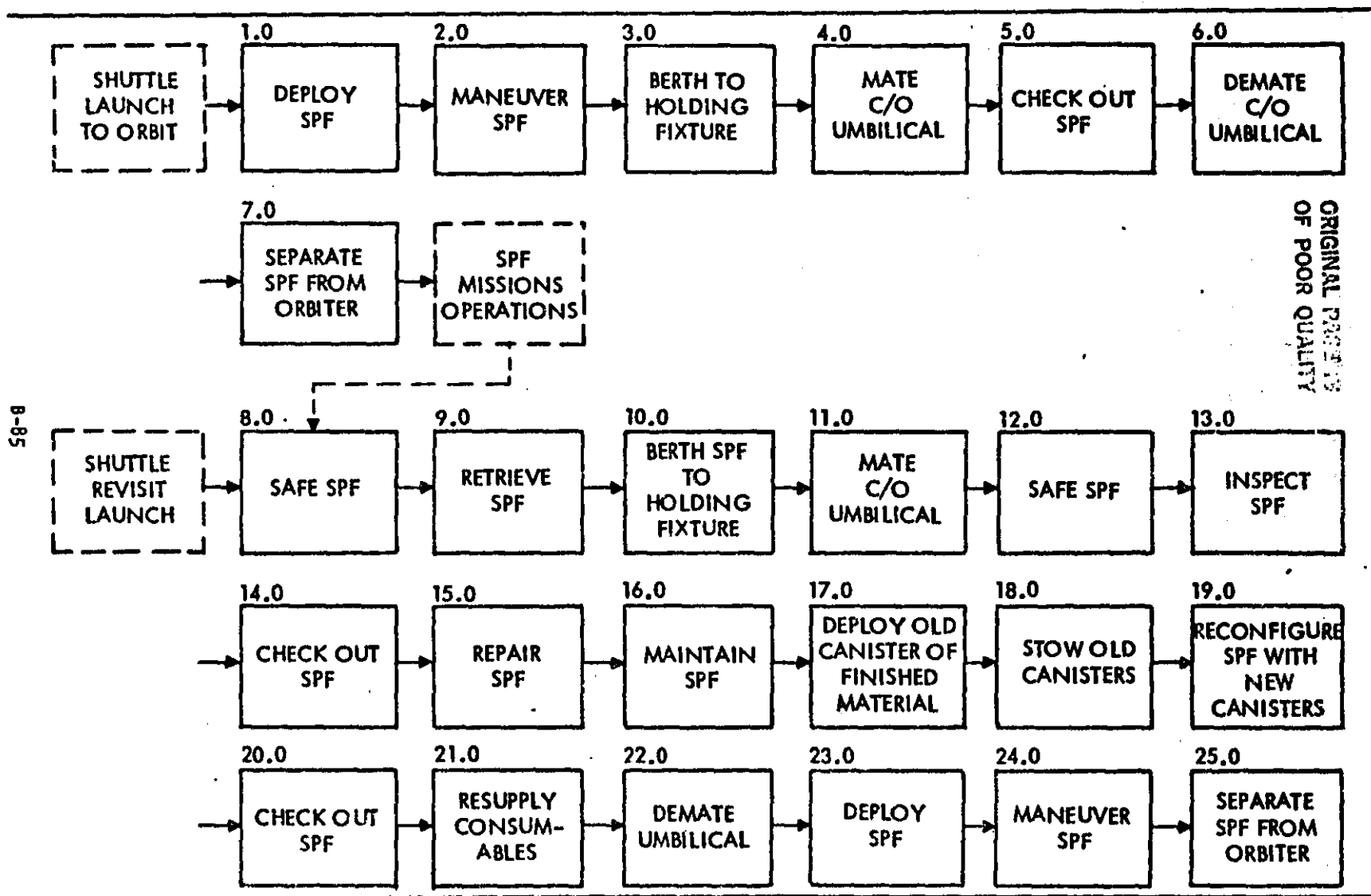
SERVICING ACTIVITY DATA

FUNCTION ITEM	COMMSAT/SOC Servicing 11.0 & 18.0 Manuever & Mate COMMSAT & OTV	ATTACHMENT	
METHOD	By SOC	PAGE	
SUBJECT	Method Description		
<p>(1) Rotate OTV 90° to service fixture (PIDA device rotates).</p> <p>(2) Activate manipulator and lock on to COMMSAT.</p> <p>(3) COMMSAT released and maneuvered towards OTV.</p> <p>(4) Manipulator berths COMMSAT to SOC.</p>			
<p>ORIGINAL PAGE IS OF POOR QUALITY</p>			

SERVICING ACTIVITY DATA

FUNCTION ITEM	COMMSAT/SOC Servicing 19 through 23 C/O & Launch COMMSAT/ OTV Assembly	ATTACHMENT	
METHOD	By SOC	PAGE	
SUBJECT Method Description			
			
<ol style="list-style-type: none"> (1) Re-activate COMMSAT systems. (2) Checkout integrated systems. (3) Supply OTV with consumables (EVA operation). (4) Demate OTV umbilical (EVA operation). (5) Manipulator locks on assembly. (6) Release PIDA device latches. (7) Manipulator maneuvers assembly clear and releases same. (8) OTV activated via RF, launching COMMSAT to GEO. <p style="text-align: right;">ORIGINAL PHOTO OF POOR QUALITY</p>			

SPACE PROCESSING FACILITY -- ORBITER SERVICING



B-85



SERVICING ACTIVITY DATA

SCENARIO: SPF/Orbiter Servicing

ACTIVITY: Initial Delivery

DESCRIPTION: The scenario includes the initial launch, deployment, checkout and release of the SPF into its parking orbit and the Shuttle revisit to exchange processing experiment cannisters. For the initial launch, fueling provisions are not required. Refueling during revisits will be accomplished by exchanging the entire ACS package.

SUPPORT EQUIPMENT: As listed below.

SPF PROVISIONS:

- (1) Grapple Fixture
- (2) PIDA Head Fittings
- (3) SPF/Orbiter System Interface
- (4) Module Latching & Release Mechanism
- (5) Experiment Cannister Latching & Release Mechanism
- (6) Replaceable Module & Cannister Design
- (7) Communication & Data Link With Orbiter & Ground OCC

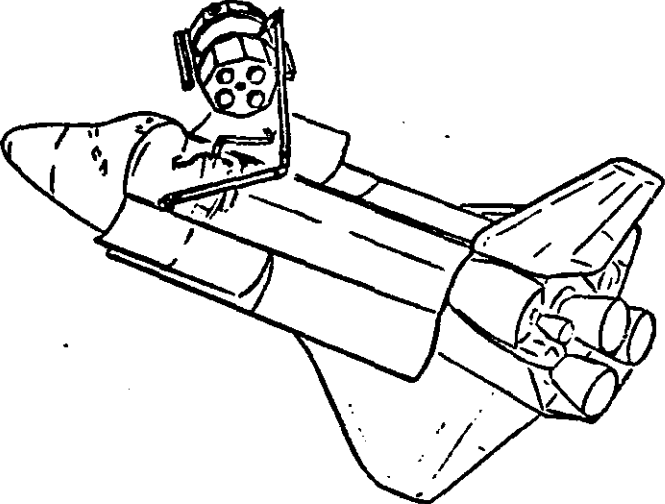
ORBITER PROVISIONS:

- (1) Scuff Plates
- (2) HPA
- (3) SPF/Orbiter Umbilical
- (4) Spec
- (5) Module & Cannister Storage & Retrieval System
- (6) MMU
- (7) Communication & Data Link With SPF & Its Ground OCC
- (8) SPF Control & Monitor Station

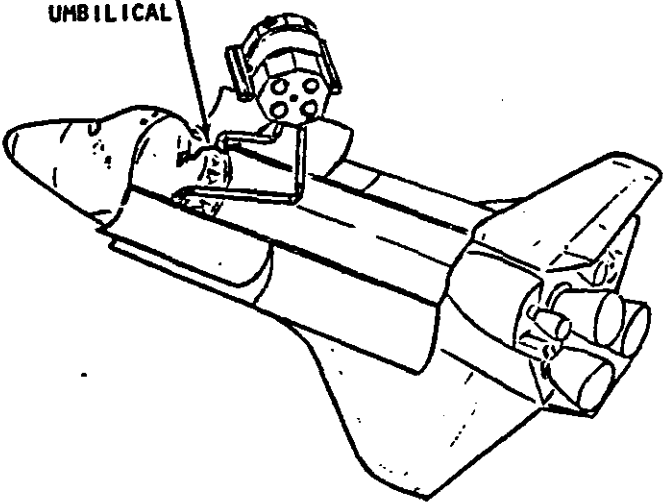
SERVICING ACTIVITY DATA

FUNCTION ITEM	SPF/Orbiter Servicing Delivery & Initial Check Space Processing Facility From Orbiter	ATTACHMENT	
METHOD	PAGE		
SUBJECT	Operation Identification		
<p>The diagram illustrates the servicing activity components on a Space Shuttle Orbiter. Labels with leader lines point to the following parts: HPA (High Pressure Air) at the nose, UMBILICAL along the side, RMS (Remote Manipulator System) at the end of the arm, and SPF (Space Processing Facility) as the payload being delivered.</p>			
<p>SCENARIO: Deliver satellite (SPF) to orbit. Revisit & perform service functions.</p> <ul style="list-style-type: none"> o Open payload bay doors. o Deploy RMS & check functions. o Deploy HPA & check functions. 			
<p>ORIGINAL PHOTO OF POOR QUALITY</p>			

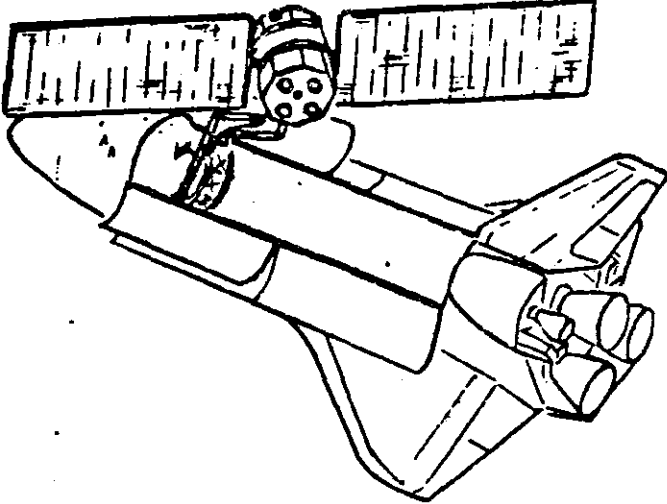
SERVICING ACTIVITY DATA

FUNCTION ITEM	SPF/Orbiter Servicing 1.0 Deploy & 2.0 Maneuver Space Processing Facility From Orbiter	ATTACHMENT		
METHOD		PAGE		
SUBJECT	Method Description			
				
<p>(1) Activate RMS and lock-on to SPF.</p> <p>(2) Remove SPF from orbiter bay.</p> <p>(3) Maneuver SPF for attachment to HPA.</p> <p>ORIGINAL PAGE IS OF POOR QUALITY</p>				

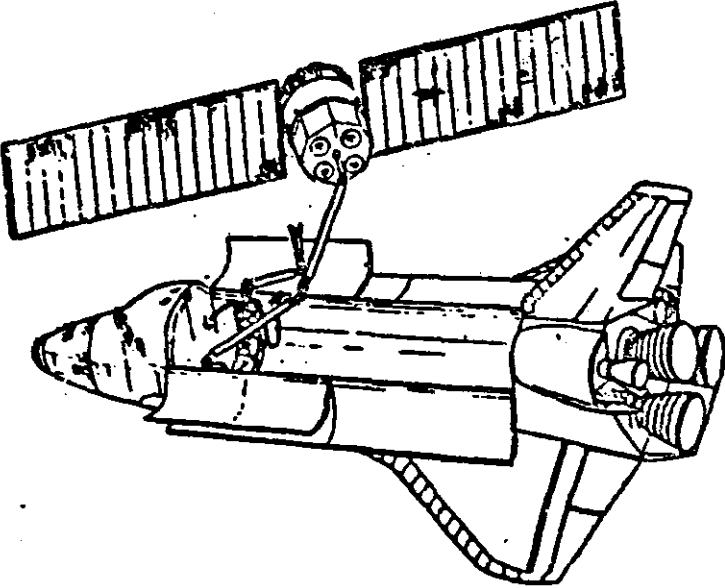
SERVICING ACTIVITY DATA

FUNCTION ITEM	SPF/Orbiter Servicing 3.0 Berth & 4.0 Mate Umbilical Space Processing Facility From Orbiter	ATTACHMENT	
METHOD	PAGE		
SUBJECT	Method Description		
			
<p>(1) Berth SPF to HPA via RMS.</p> <p>(2) RMS locks onto umbilical.</p> <p>(3) RMS connects umbilical to SPF.</p> <p>ORIGINAL PAGE 03 OF POOR QUALITY</p>			

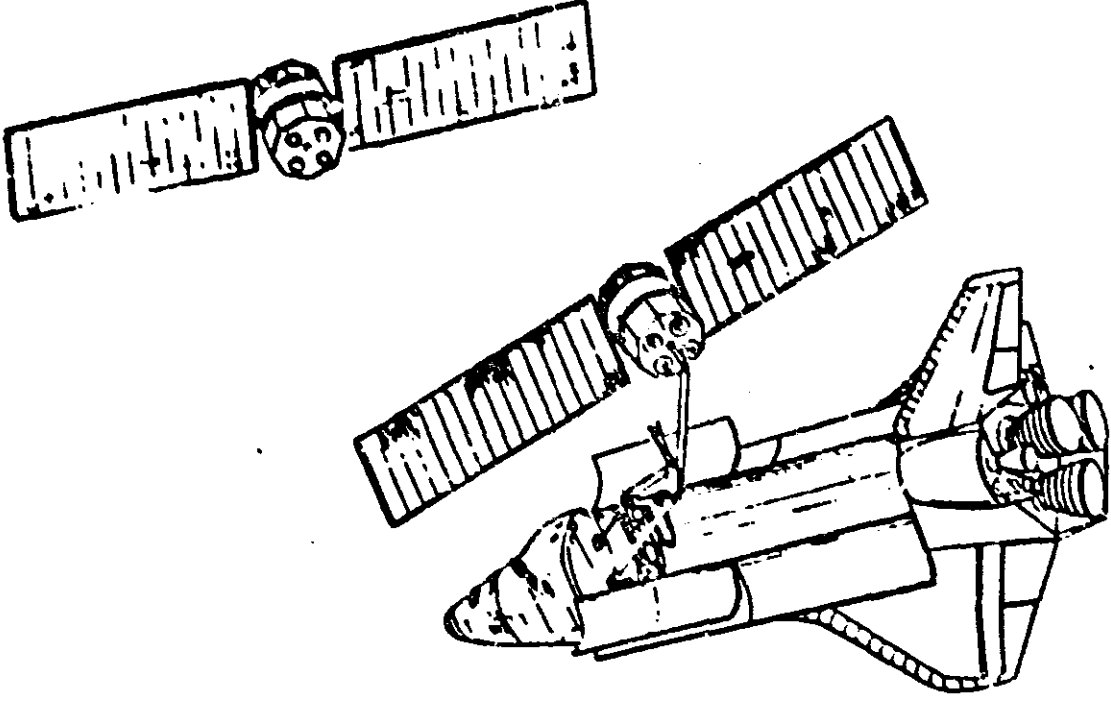
SERVICING ACTIVITY DATA

FUNCTION ITEM	SPF/Orbiter Servicing 5.0 & 6.0 C/O & Demate Umbilical Space Processing Facility From Orbiter	ATTACHMENT		
METHOD		PAGE		
SUBJECT	Method Description			
				
<p>(1) Checkout SPF systems.</p> <ul style="list-style-type: none"> o Command link o Power o Thermal o ACS <p>(2) RMS disconnects and stows umbilical.</p> <p style="text-align: center;">ORIGINAL PAGE IS OF POOR QUALITY</p>				

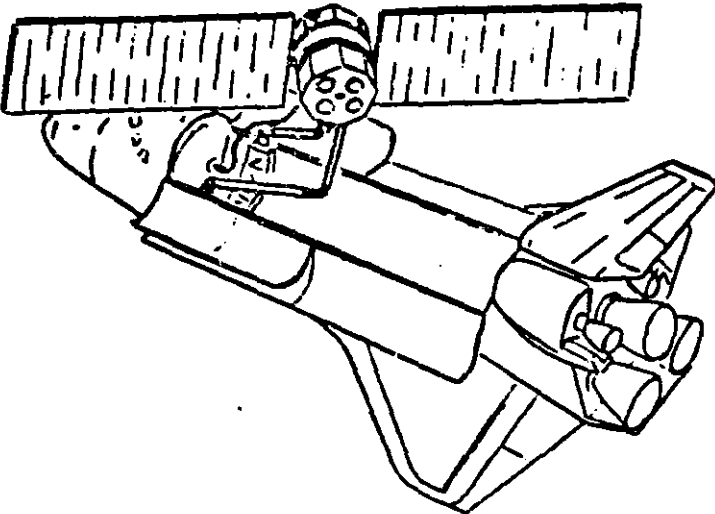
SERVICING ACTIVITY DATA

FUNCTION ITEM	SPF/Orbiter Servicing 7.0 Separate & Release Space Processing Facility from Orbiter	ATTACHMENT	
METHOD		PAGE	
SUBJECT	Method Description		
			
<ol style="list-style-type: none">(1) RMS locks onto SPF.(2) RMS removes SPF from HPA.(3) Satellite released.(4) SPF systems activated by RF.(5) Orbiter leaves.			
ORIGINAL PAGE IS OF POOR QUALITY			

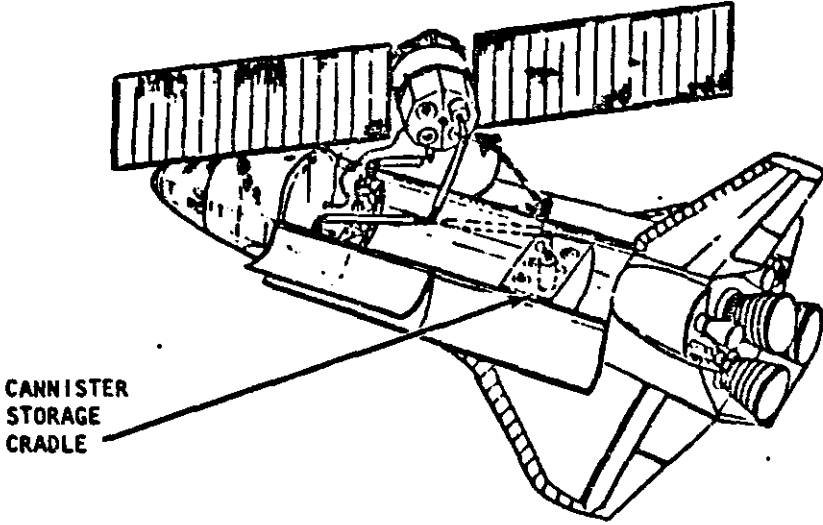
SERVICING ACTIVITY DATA

FUNCTION ITEM	SPF/Orbiter Servicing 8.0 & 9.0 Safe & Retrieve Space Processing Facility From Orbiter	ATTACHMENT	
METHOD		PAGE	
SUBJECT Method Description			
			
<p>After completion of SPF mission operation, orbiter returns to a proximity orbit:</p> <ol style="list-style-type: none"> (1) Stationkeep (2) Safe SPF system via RF. (3) Recapture SPF via RMS. (4) Maneuver SPF for attachment to HPA. <p style="text-align: right;">ORIGINAL PAGE IS OF POOR QUALITY</p>			

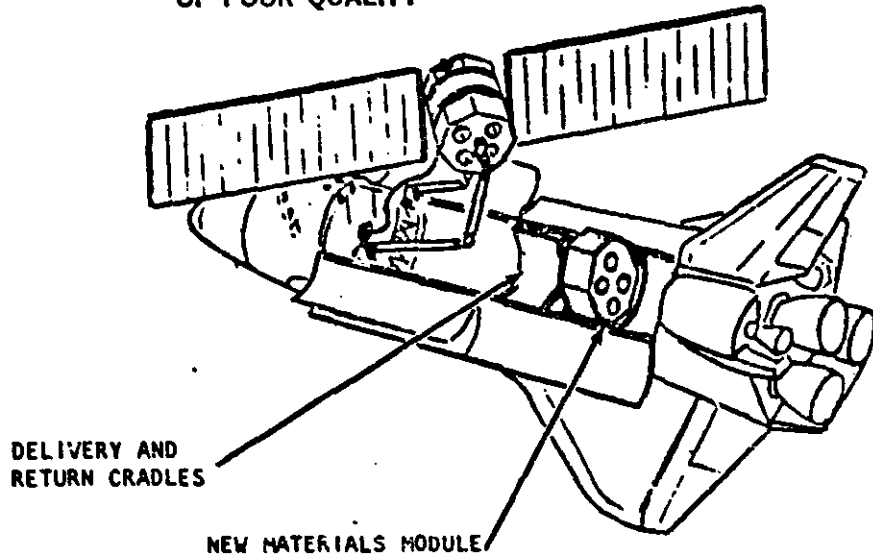
SERVICING ACTIVITY DATA

FUNCTION ITEM	SPF/Orbiter Servicing 10.0 through 16.0 Berth & C/O Operations.	ATTACHMENT	
METHOD	Space Processing Facility From Orbiter	PAGE	
SUBJECT	Method Description		
<p data-bbox="698 447 954 520" style="text-align: center;">ORIGINAL PAGE IS OF POOR QUALITY</p> 			
<p>RMS berths SPF to HPA.</p> <p>RMS locks on to umbilical.</p> <p>RMS connects umbilical to SPF.</p> <p>All systems verified safe.</p> <p>Visual check of SPF with RMS CCTV assist.</p> <p>Systems check via umbilical.</p> <p>Repair and maintain SPF via EVA.</p>			

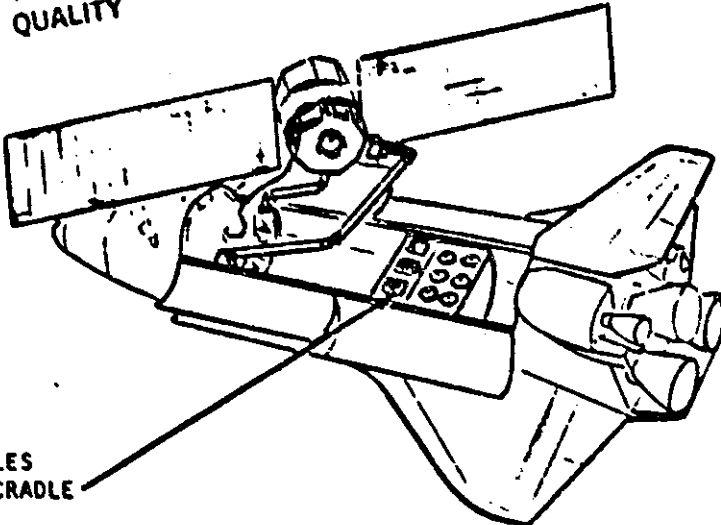
SERVICING ACTIVITY DATA

FUNCTION ITEM	SPF/Orbiter Servicing 17.0 thru 19.0 Cannister Changeout Space Processing Facility From Orbiter	ATTACHMENT	
METHOD		PAGE	
SUBJECT	Method Description		
<p style="text-align: center;">ORIGINAL PAGE IS OF POOR QUALITY</p>  <p>CANNISTER STORAGE CRADLE</p>			
<ol style="list-style-type: none"> (1) RMS locks onto used SPF cannister. (2) RMS translates cannister to orbiter bay. (3) Cannister inserted into storage unit. (4) RMS removes new materials cannister. (5) Cannister inserted into empty SPF orific. (6) RMS locks onto next used cannister and above procedure repeated until all cannisters have been exchanged. 			

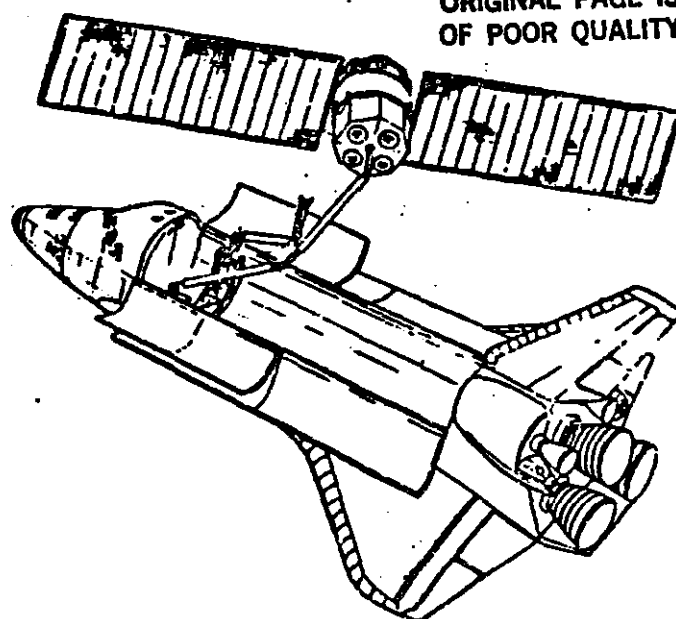
SERVICING ACTIVITY DATA

FUNCTION ITEM	SPF/Orbiter Servicing 17.0 thru 20.0 Module Changeout	ATTACHMENT	
METHOD	Space Processing Facility From Orbiter	PAGE	
SUBJECT	Alternate Method Description		
<p>ORIGINAL PAGE IS OF POOR QUALITY</p>  <p>DELIVERY AND RETURN CRADLES</p> <p>NEW MATERIALS MODULE</p>			
<ol style="list-style-type: none"> (1) RMS locks onto materials module. (2) Locking latches released. (3) RMS translates material module to bay. (4) Used module deposited into support cradle. (5) RMS released and translated to new module. (6) RMS locks onto new module. (7) New module translate to SPF. (8) Module locked in place. (9) RMS returns to rest position. (10) All SPF systems checkedout. <p>(NOTE: Identical procedure used for exchange of controls module.)</p>			

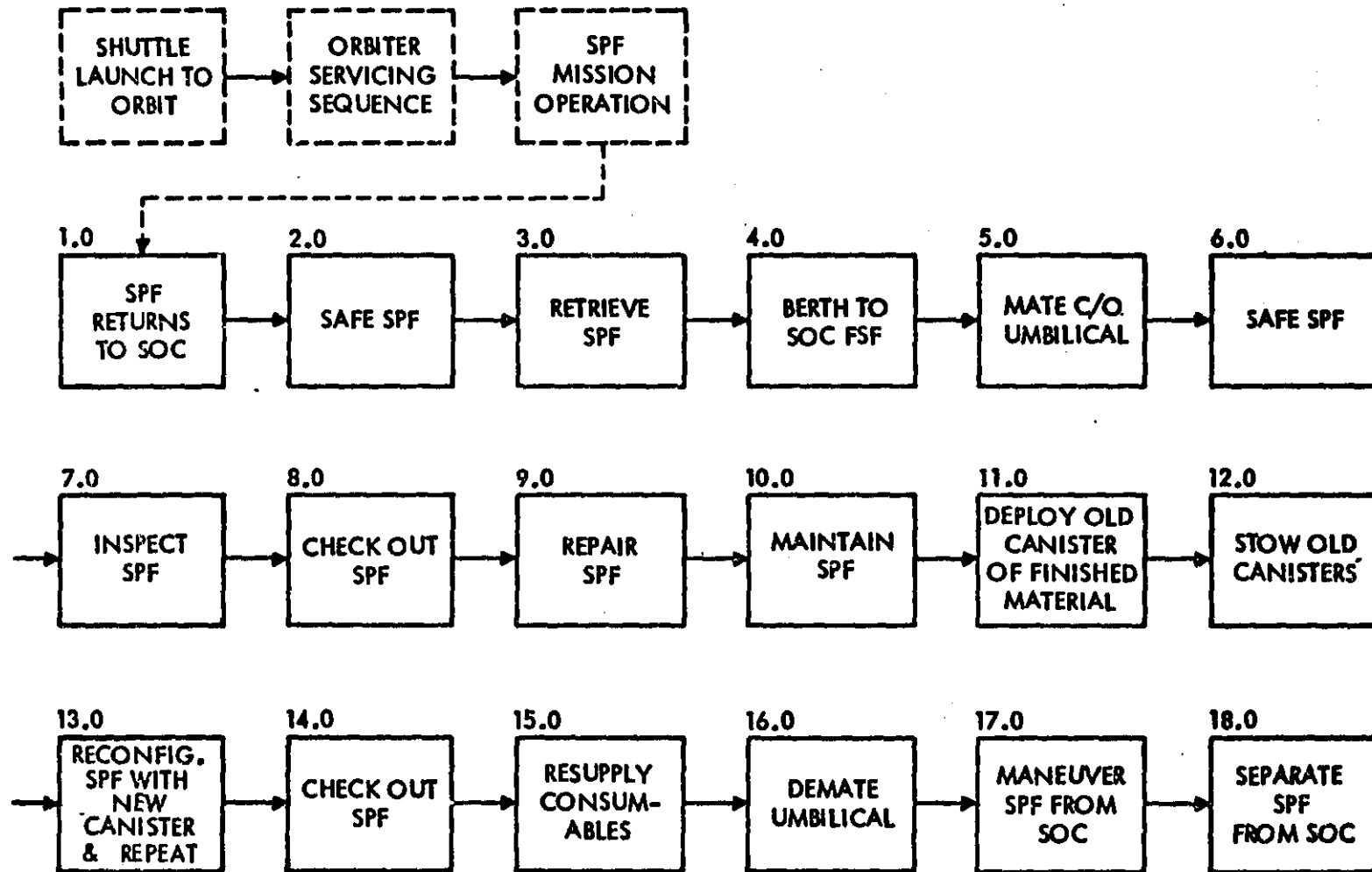
SERVICING ACTIVITY DATA

FUNCTION ITEM	SPF/Orbiter Servicing 21.0 Resupply Consumables	ATTACHMENT	
METHOD	Space Processing Facility From Orbiter	PAGE	
SUBJECT	Method Description		
<p>ORIGINAL PAGE IS OF POOR QUALITY</p>  <p>CONSUMABLES STORAGE CRADLE</p>			
<ol style="list-style-type: none"> (1) RMS unscrews and locks onto ACS package. (2) RMS deposits package into storage cabinet. (3) RMS picks up replacement ACS package. (4) ACS package aligned and screwed in place. (5) Procedure repeated for second ACS. 			

SERVICING ACTIVITY DATA

FUNCTION ITEM	SPF/Orbiter Servicing 22.0 thru 24.0 Demate & Release	ATTACHMENT		
METHOD	Space Processing Facility From Orbiter	PAGE		
SUBJECT	Method Description			
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<ol style="list-style-type: none"> (1) RMS disconnects and stows umbilical. (2) RMS locks onto SPF. (3) RMS removes SPF from HPA. (4) Satellite released. (5) SPF system activated by RF. (6) Orbiter leaves. 				

SPACE PROCESSING FACILITY -- SOC SERVICING



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SERVICING ACTIVITY DATA

SCENARIO: SPF/SOC Servicing

ACTIVITY: Initial Delivery

DESCRIPTION: In contrast to SPF servicing by the orbiter, this scenario does not include the initial launch because there is no SOC involvement in that phase of the operation. Only servicing during revisits to the SOC are included as described on the following pages.

SUPPORT EQUIPMENT: As listed below.

SOC PROVISIONS:

- (1) SPF Control & Monitor Station
- (2) Communication & Data Links With SPF & Its Ground OCC
- (3) Mobile Manipulator With Standard End Effector
- (4) Spee
- (5) CCTV Camera on Mobile Manipulator
- (6) Open Cherry Picker & MMU
- (7) Retractable Umbilicals With Refueling Provisions
- (8) Module & Cannister Storage & Retrieval System

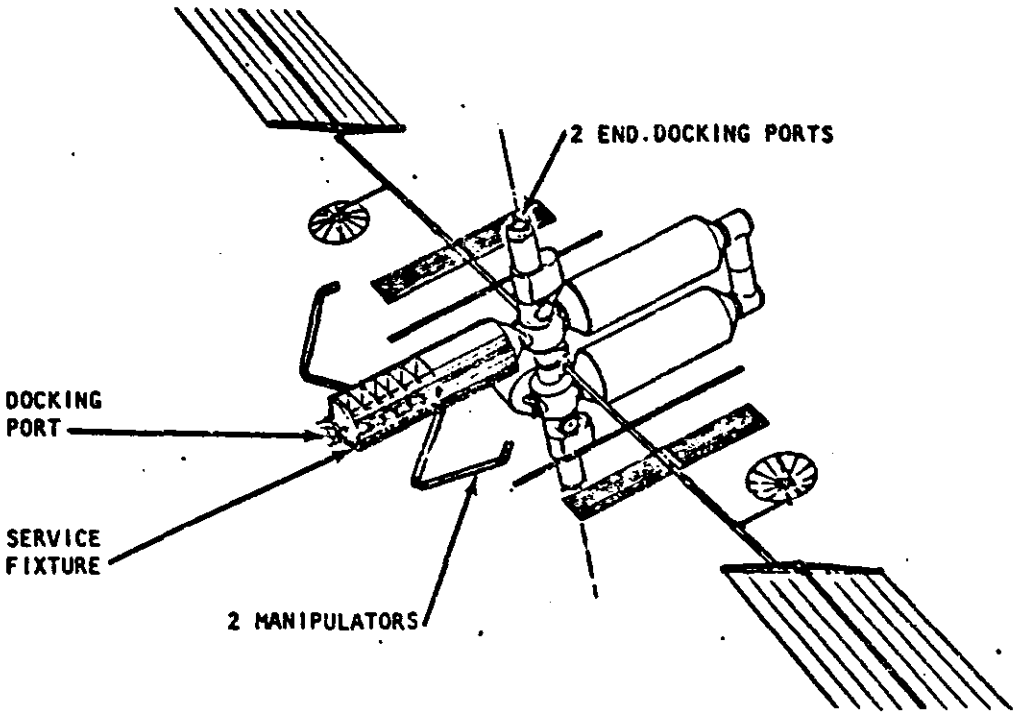
SPF PROVISIONS:

- (1) Grapple Fixture
- (2) PIDA Head Fittings
- (3) SPF/SOC System Interface
- (4) Module Latching & Release Mechanism
- (5) Experiment Cannister Latching & Release Mechanism
- (6) Replaceable Module & Cannister Design
- (7) Communication & Data Link With SOC & Ground OCC

ORBITER PROVISIONS:

- (1) Scuff Plates
- (2) HPA
- (3) Module & Cannister Storage

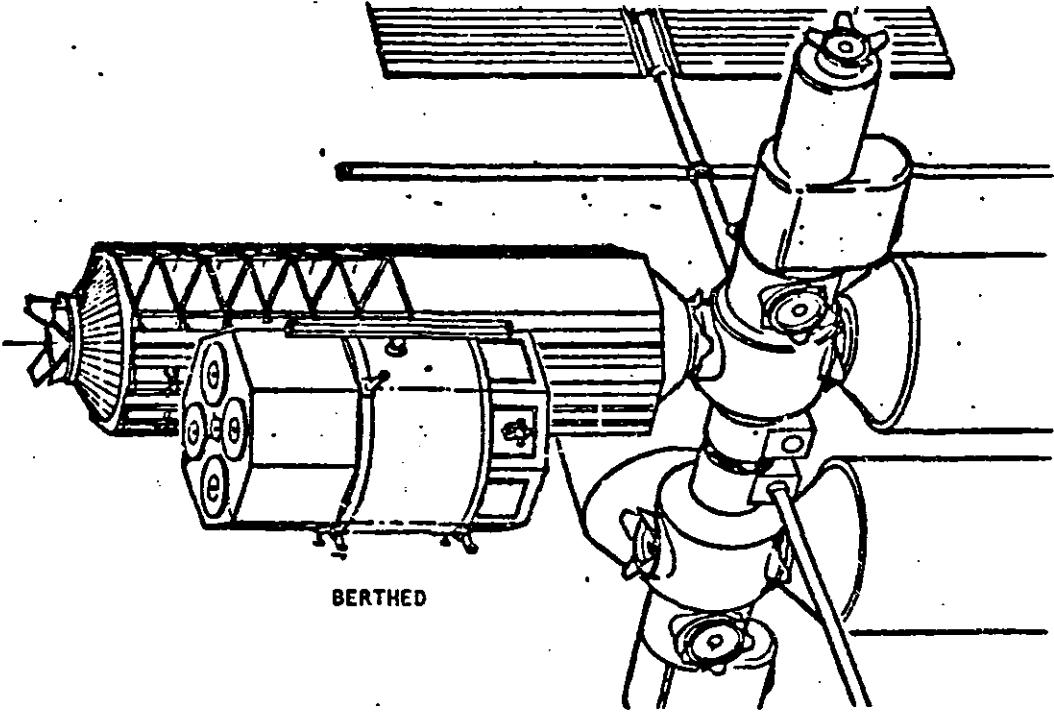
SERVICING ACTIVITY DATA

FUNCTION ITEM	SPF/SOC Servicing Turnaround Servicing	ATTACHMENT	
METHOD	Space Processing Facility At SOC	PAGE	
SUBJECT	Scenario		
			
<p>SOC is the Space Base at which turnaround servicing can be performed.</p> <p>The SPF is a free-flyer which is capable of "flying" in close enough to the SOC for capture by manipulator.</p> <p>Individual module or cannister changeout operation accomplished by manipulator with EVA assist as required.</p> <p>ORIGINAL PAGE IS OF POOR QUALITY</p>			

SERVICING ACTIVITY DATA

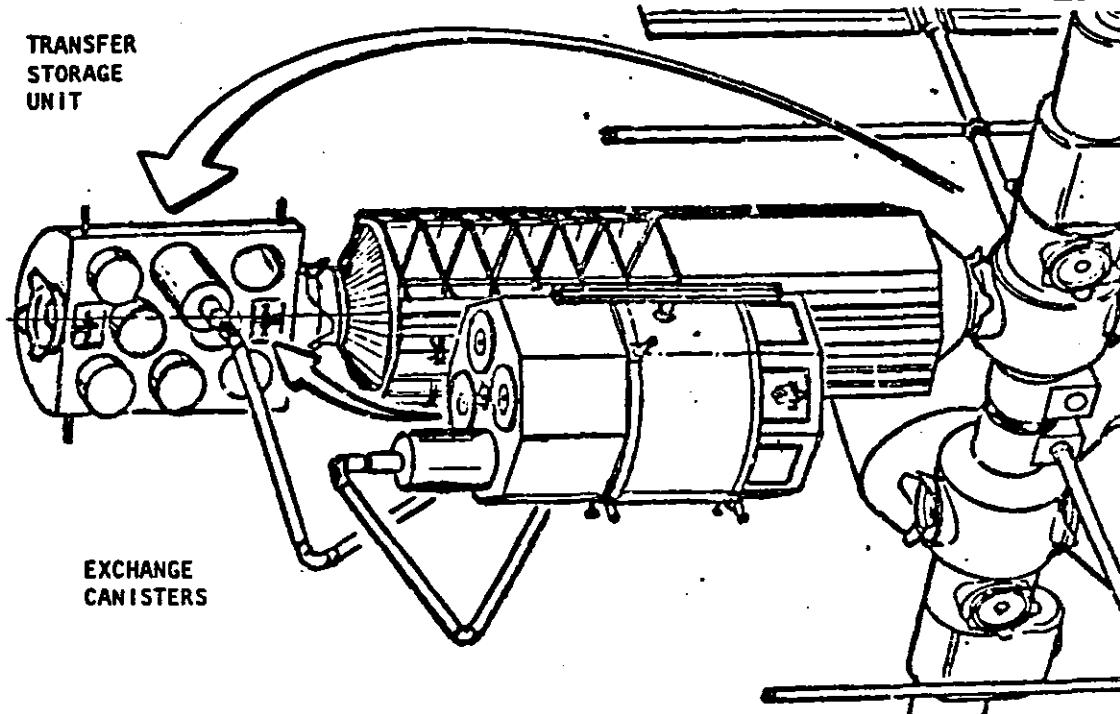
FUNCTION ITEM	SPF/SOC Servicing 1.0 thru 3.0 Safe & Capture Space Processing Facility By SOC	ATTACHMENT	
METHOD		PAGE	
SUBJECT	Method Description		
<p>ORIGINAL PAGE IS OF POOR QUALITY</p> <p>REVISIT</p> <p>CAPTURE</p>			
<ol style="list-style-type: none"> (1) SPF returns to SOC - adjacent to and within the reach envelope of the service structure. (2) Solar arrays retracted via SOC RF. (3) All SPF systems safed via SOC RF. (4) Service structure manipulator activated. (5) Manipulator captures SPF. (6) SPF transported towards service structure. 			

SERVICING ACTIVITY DATA

FUNCTION ITEM	SPF/SOC Servicing 4.0 thru 10.0 Berth & Checkout	ATTACHMENT	
METHOD	Space Processing Facility By SOC	PAGE	
SUBJECT	Method Description		
 <p style="text-align: center;">BERTHED</p>			
<ol style="list-style-type: none"> (1) Manipulator berths SPF on FIDA device. (2) Umbilical connected to interface via EVA. (3) All SPF systems verified safe. (4) Visual check of SPF by manipulator CCTV and/or EVA crewman. (5) Systems checked thru umbilical. (6) Repair and maintain SPF via EVA operations. 			
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SERVICING ACTIVITY DATA

FUNCTION ITEM	SPF/SOC Servicing 11.0 thru 15.0 Changeout Items	ATTACHMENT	
METHOD	Space Processing Facility By SOC	PAGE	
SUBJECT	Method Description		

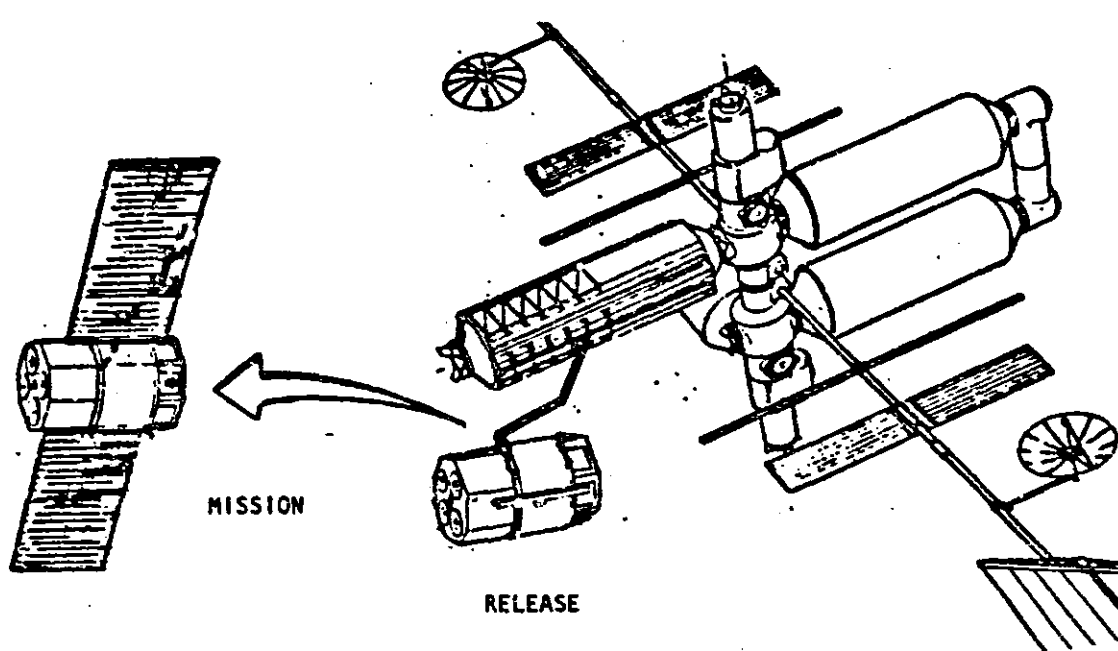


The diagram illustrates the servicing process. A robotic manipulator arm is shown on the right, reaching towards a large cylindrical storage unit on the left. A curved arrow indicates the transfer of the storage unit from its stowed position to the service fixtures. Below the storage unit, a cluster of exchange canisters is shown. The manipulator is depicted interacting with these canisters, performing the exchange process. Labels 'TRANSFER STORAGE UNIT' and 'EXCHANGE CANISTERS' are placed near their respective components.

- (1) Manipulator transfers storage unit from its stowed location (i.e., spare docking port or resupply by orbiter) and berths same to service fixtures end docking port.
- (2) Manipulator locks onto used cannister and transfers same to storage unit.
- (3) A new cannister is removed from the storage unit and placed into the empty SPF orific.
- (4) Manipulator removes second used cannister, repeating procedure until all cannisters have been exchanged.
- (5) SPF systems checkout.
- (6) Manipulator exchanges consumables with EVA assist.

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SERVICING ACTIVITY DATA

FUNCTION ITEM	SPF/SOC Servicing 16.0 thru 18.0 Demate & Release Space Processing Facility By SOC	ATTACHMENT	
METHOD		PAGE	
SUBJECT	Method Description		
 <p>The diagram illustrates the mission sequence for SPF/SOC Servicing. It shows a Space Processing Facility (SPF) being released from a Spacecraft (SOC) and then moving towards its mission rendezvous. The diagram includes labels for 'MISSION' and 'RELEASE'.</p>			
<ol style="list-style-type: none"> (1) EVA crewman disconnects umbilical. (2) Manipulator locks onto SPF. (3) PIDA device releases SPF. (4) Manipulator maneuvers SPF away from SOC and releases same. (5) SOC control activates all SPF systems and deploys solar arrays. (6) All systems go - ACS fires taking SPF to its mission rendezvous. 			
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APPENDIX C

DETAILED TIME & MANPOWER ESTIMATES

APPENDIX C.
DETAILED TIME AND MANPOWER ESTIMATES

This appendix contains several tables listing detailed estimates of time, crew requirements, and man-hours required for each task and scenario considered in Section 4.4.

The material is generally arranged in "packages" of information dealing with one scenario at a time. That is, the time and manpower estimates for ground servicing of the OTV are presented in the first package, the estimates for OTV servicing at the SOC are next presented, and so on, through the communications satellite and space processing facility scenarios. The level of detail of analysis is different for some scenarios than for others, as a consequence of specific concerns for potential impact on operations costs of the different types of operations. However, each format generally includes at least the following:

1. A table giving elapsed time, crew size, man-hours, and rationale for each function.
2. A timeline chart.

In some cases, there is included a detailed breakdown of time, crew size, man-hours, etc., for specific, limited portions of the activity. These may be preliminary estimates which do not correspond exactly to items 1 or 2 above.

In addition to the above, there is a table of general guidelines for typical time elements used in the various estimates.

TABLE C-1. TIME RATIONALE - OTV GROUND SERVICING

TASK NO.	TASK DESCRIPTION	ELAPSED TIME (HR)	CREW QTY	MAN-HR	RATIONALE
1.0	RETURN OTV TO ORBITER (MONITOR FLT)	4.0	4	16	CROSS-TRAINED CREW, INCL. RMS WARMUP
2.0	SAFE OTV (DEACTIVATE MAIN ENGINE) & PROXIMITY MANEUVER	0.5	4	2	INCL. RMS CHECKOUT
3.0	RETRIEVE OTV (RMS GRAPPLE & DEACTIVATE ATTITUDE CONTROL PROPULSION SYSTEM)	0.5	4	2	BASED ON SIMULATION RESULTS
4.0	BERTH OTV TO HOLDING FIXTURE	0.5	4	2	<u>ENGR. ESTIMATE</u> ; ASSUMES LIGHT SIDE ACTIVITY
5.0	SAFE OTV & INSPECT FOR LEAKS	2.0	4	8	<u>ENGR. ESTIMATE</u>
6.0	STOW OTV IN PAYLOAD BAY	0.5	4	2	<u>EST. BY SIMILARITY TO SPAR SIMULATION RESULTS</u>
7.0	RETURN TO EARTH	6.0	4	24	5-HR BARBECUE; 1-HR ENTRY (MIN)
8.0	SERVICE ON GROUND	-	-	-	(OVERALL TITLE ONLY)
9.0	SAFE ORBITER	2.0	-	-	<u>BASED ON STAR 20 TIMELINE FOR ORBITER</u>
10.0	TRANSPORT TO OPF				
11.0	UNSTOW OTV	20.0	3	60	<u>EST. FROM SIMILARITY TO ORBITER SCHEDULE FOR TURNAROUND (STAR 20)</u>
12.0	TRANSPORT OTV TO OTV P.F.				

TABLE C-1. TIME RATIONALE - OTV GROUND SERVICING (CONT.)

TASK NO.	TASK DESCRIPTION	ELAPSED TIME (HR)	CREW QTY	MAN-HR	RATIONALE
13.0	INSPECT OTV	4.0	6	24	COMPATIBLE WITH ORBITER TURNAROUND SCHEDULE (STAR 20)
14.0	MATE CHECKOUT GSE				
15.0	TEST OTV	4.0	6	24	ENGR. ESTIMATE
16.0	PERFORM SCHEDULED REPAIR	24.0	3	72	40 HR ELAPSED TIME (PARALLEL OPERATIONS); SIMILARITY TO ORBITER TIME REQUIREMENTS (STAR 20)
17.0	PERFORM UNSCHEDULED REPAIR	16.0	3	120	
18.0	MAINTAIN OTV	5.0	6	30	ENGR. ESTIMATE
19.0	CHECK OUT OTV				
20.0	DEMATE CHECKOUT GSE				
21.0	VERIFY OTV INTEGRATION WITH ORBITER (CIT)	8.0	6	48	ENGR. ESTIMATE
22.0	TRANSPORT TO LAUNCH PAD				
23.0	RESUPPLY NON-CRYO CONSUMABLES	27.0	6	142	BASED ON ORBITER TURNAROUND TIME SEGMENT (STAR 20)
24.0	STOW OTV IN ORBITER PAYLOAD BAY				

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TABLE C-1. TIME RATIONALE - OTV GROUND SERVICING (CONT.)

TASK NO.	TASK DESCRIPTION	ELAPSED TIME (HR)	CREW QTY	MAN-HR	RATIONALE
25.0	RESUPPLY CRYO CONSUMABLES	6.0	-	-	} MANPOWER BY NASA CONTRACTOR (ORBITER PAGED TIME ELEMENTS)
26.0	SHUTTLE LAUNCH OF OTV	4.0	-	-	
	SUBTOTAL	134.0		576	
27.0	BOOST & CIRCULARIZE ORBIT; CHECK OUT OTV	6.0	4	24	RENDEZVOUS WITH COMMUNICATIONS SATELLITE IN LEO
	TOTAL	140.0	4.29 AVG.*	600	

*CALCULATED BY: $\frac{\text{TOTAL MAN-HOURS}}{\text{TOTAL ELAPSED TIME}}$

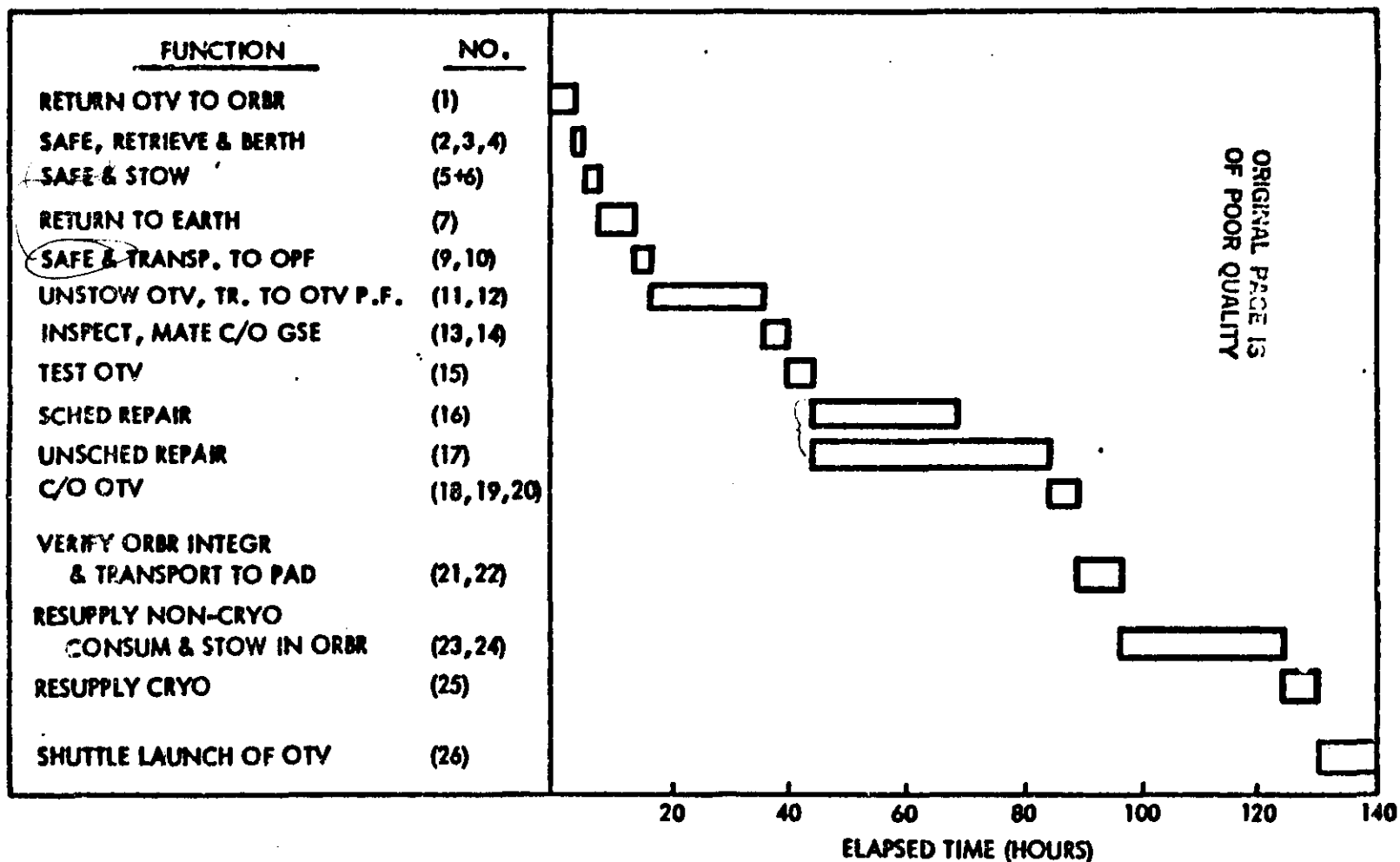


FIGURE C-1. CHECKOUT/SERVICING TIMELINE OTV - GROUND SERVICING

TABLE C-2. TIME RATIONALE - OTV TURNAROUND AT SOC

TASK NO.	TASK DESCRIPTION	ELAPSED TIME (HR)	CREW QTY	MAN-HR	RATIONALE
1.0	RETURN OTV TO SOC (PREPARATION BY CREW)	^{5-6 hrs} 4.0	5	20.0	PLANNING INCLUDES ALL ASSIGNED CREW; ACQUISITION & MONITORING INCLUDED
2.0	SAFE OTV (DEACTIV. MAIN ENGINE) AND PERFORM PROXIMITY MANEUVERS (STATIONKEEPING)	0.5 ^{1 hr}	3	1.5	PRELIMINARY ESTIMATE
3.0	DOCK OTV TO SOC	0.5	4	2.0	SIMILAR TO ORBITER DOCKING; SAFETY-CRITICAL MANEUVER; EXTRA "EYES" REQ'D
4.0	SAFE OTV (DEACTIVATE ATTITUDE CONTROL SYSTEM)	0.3	4	1.2	MULTIPLE CREW AT READINESS
5.0	MANEUVER OTV TO FSF (USING MANIP.)	0.5	5	2.5	RMS OPERATOR, SOC CDR, FSF OPERATOR, OTV DIRECTOR OBSERVER
6.0	MATE CHECKOUT UMBILICALS	0.5	5	2.5	RMS OPERATION, SIMILAR TO SPAR DATA
7.0	(a) SAFE OTV (POWER, FLUIDS) (b) INSPECT OTV (RMS TV CAMERA)	0.5 2.0	4 4	2.0 8.0	} ENGR. ESTIMATES
8.0	TEST OTV (ELECTRONICS & MECH. ACTUATORS-VERIFY ONBOARD TEST EQUIPMENT DATA)	1.0	4	4.0	
9.0	PERFORM SCHEDULED MAINTENANCE	24.0	3	72.0	TWO MODULES REPLACED @ 2 HR EACH SERIALY

TABLE C-2. TIME RATIONALE - OTV TURNAROUND AT SOC (CONT.)

TASK NO.	TASK DESCRIPTION	ELAPSED TIME (HR)	CREW QTY	MAN-HR	RATIONALE
10.0	PERFORM UNSCHEDULED (CORRECTIVE) MAINT. REPAIR (RMS REPLACEMENT OF LRU'S)	10.0	3	40.0	3 HR PER FAILURE, 2 FAILURES IN 50 HR (EST.); MATURE, RELIABLE DESIGN
11.0	MAINTAIN OTV (NOT USED-SEE 9.0)	-	-	-	DUPLICATION-NOT USED
12.0	CHECKOUT OTV	1.5	4	6	0.75 HR PER FAILURE, 2 FAILURES IN 50 HR (EST.)
13.0	RESUPPLY CONSUMABLES	6.8	4	24	PRELIMINARY ESTIMATE, ASSUMES ADEQUATE LINE SIZE
	TOTAL	57.3	3.75 AVG*	193.7	

*CALCULATED BY: $\frac{\text{TOTAL MAN-HOURS}}{\text{TOTAL ELAPSED TIME}}$

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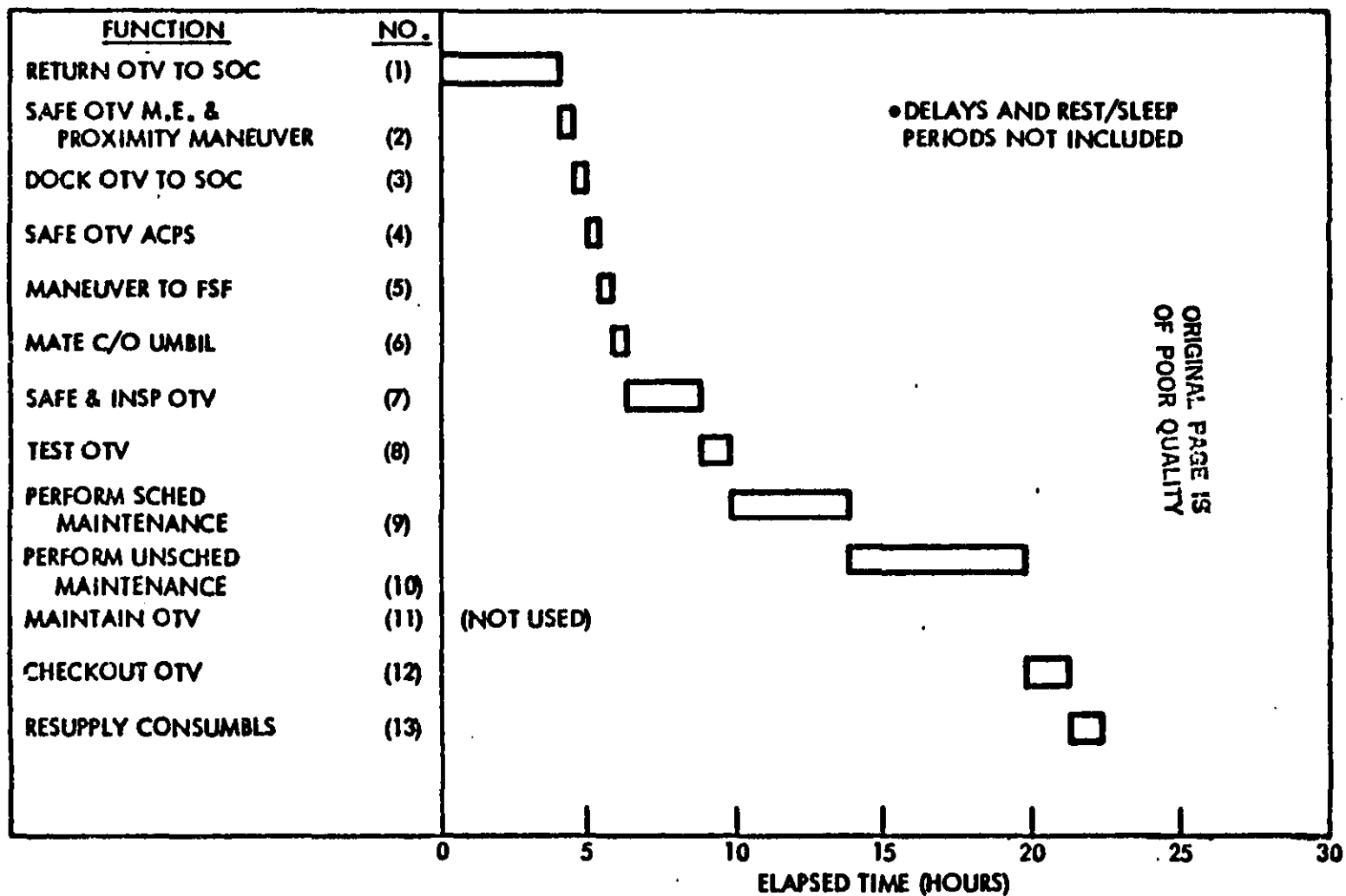


FIGURE C-2. CHECKOUT/SERVICING TIMELINE
OTV TURNAROUND AT SOC
(WITHOUT P/L MATE)

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TABLE C-3. TIME RATIONALE - COMMUNICATION SATELLITE SERVICING AT ORBITER

TASK NO.	TASK DESCRIPTION	ELAPSED TIME (HR)	CREW QTY	MAN-HR	RATIONALE
1.0	DEPLOY COMM SAT FROM PAYLOAD BAY	0.3	3.0	0.9	BASED ON SPAR SIM. DATA (TABLE A-9)
2.0	MANEUVER COMMUNICATION SATELLITE	0.3	3.0	0.9	"
3.0	BERTH TO HOLDING FIXTURE	0.2	3.0	0.6	"
4.0	MATE CHECKOUT UMBILICAL	0.5	3.0	1.5	ENGR. ESTIMATE
5.0	PRELIM. CHECKOUT OF COMM SAT	4.9	3.0	14.5	FROM TABLE A-5
6.0	DEPLOY APPENDAGES (ANT., RADIATORS)	18.7	3.8	70.9	FROM TABLE A-5
7.0	CHECK OUT COMMUNICATION SATELLITE	12.8	2.7	37.6	"
8.0	SAFE COMMUNICATION SATELLITE	0.5	3.0	1.5	"
9.0	DEMATE UMBILICAL	0.5	3.0	1.5	"
10.0	RELEASE COMM SAT (PARKING ORBIT)	0.5	3.0	1.5	"
11.0	DEPLOY OTV FROM PAYLOAD BAY	0.3	3.0	0.9	BASED ON TABLE A-9
12.0	MANEUVER OTV	0.3	3.0	0.9	BASED ON TABLE A-9
13.0	BERTH OTV TO HOLDING FIXTURE	0.2	3.0	0.6	ENGR. ESTIMATE
14.0	MATE OTV UMBILICAL	0.5	3.0	1.5	FROM TABLE A-5
15.0	CHECK OUT OTV	2.5	2.0	5.0	FROM TABLE A-5
16.0	RETRIEVE COMMUNICATION SATELLITE	1.0	3.0	3.0	ENGR. ESTIMATE
17.0	MATE OTV & COMM SAT	1.0	3.0	3.0	FROM TABLE A-5
18.0	CHECK OUT INTEGRATION SYSTEM	1.0	4.0	4.0	"
19.0	DEMATE OTV UMBILICAL	0.5	3.0	1.5	FROM TABLE A-5, NO SERVICING REQ'D; FUELED ON GROUND
20.0	SEPARATE INTEGRATION PAYLOAD	2.8	3.0	8.5	FROM TABLE A-5
21.0	LAUNCH TO GEO	1.5	3.0	4.5	FROM TABLE A-5
	TOTALS	50.8	63.0	164.8	
	AVERAGE PER TASK	2.4	3.0	7.8	

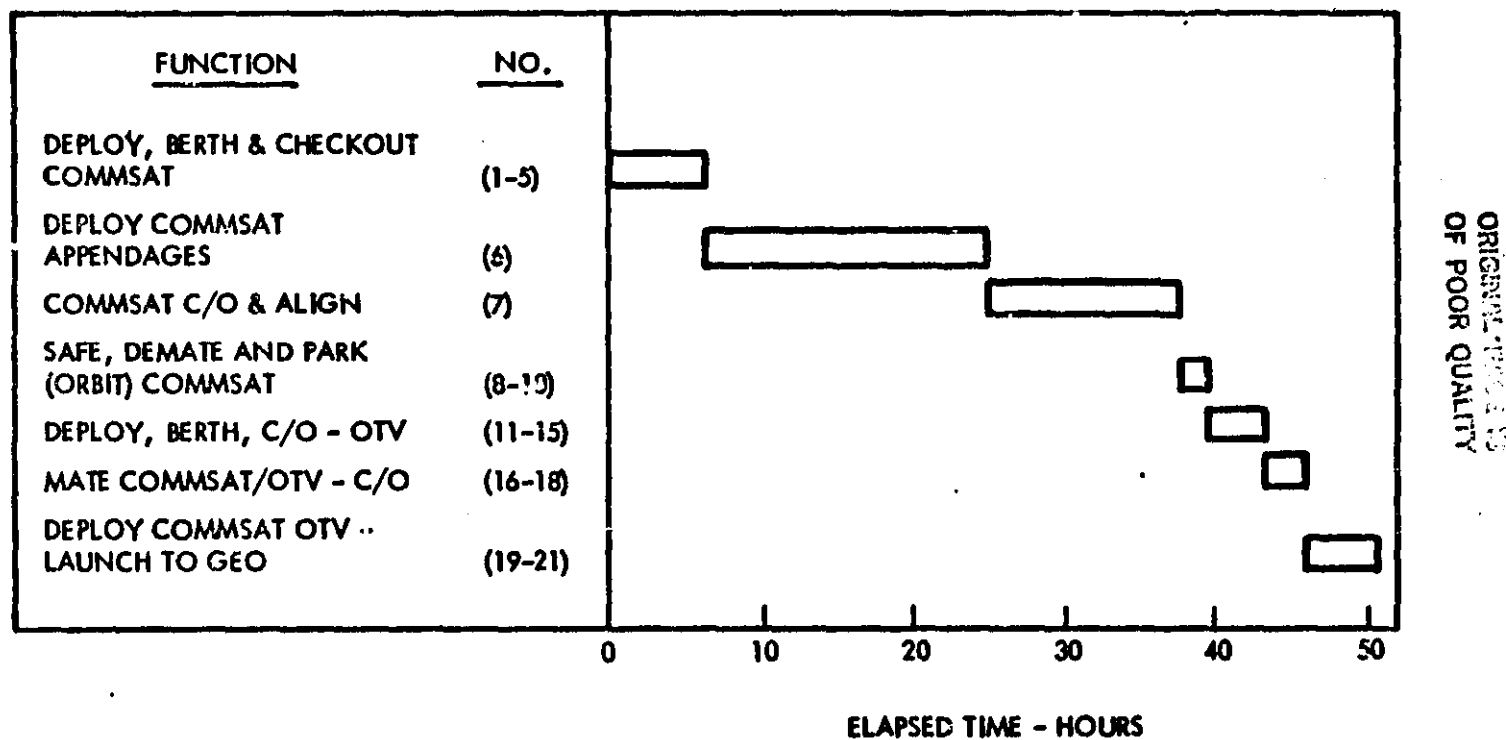
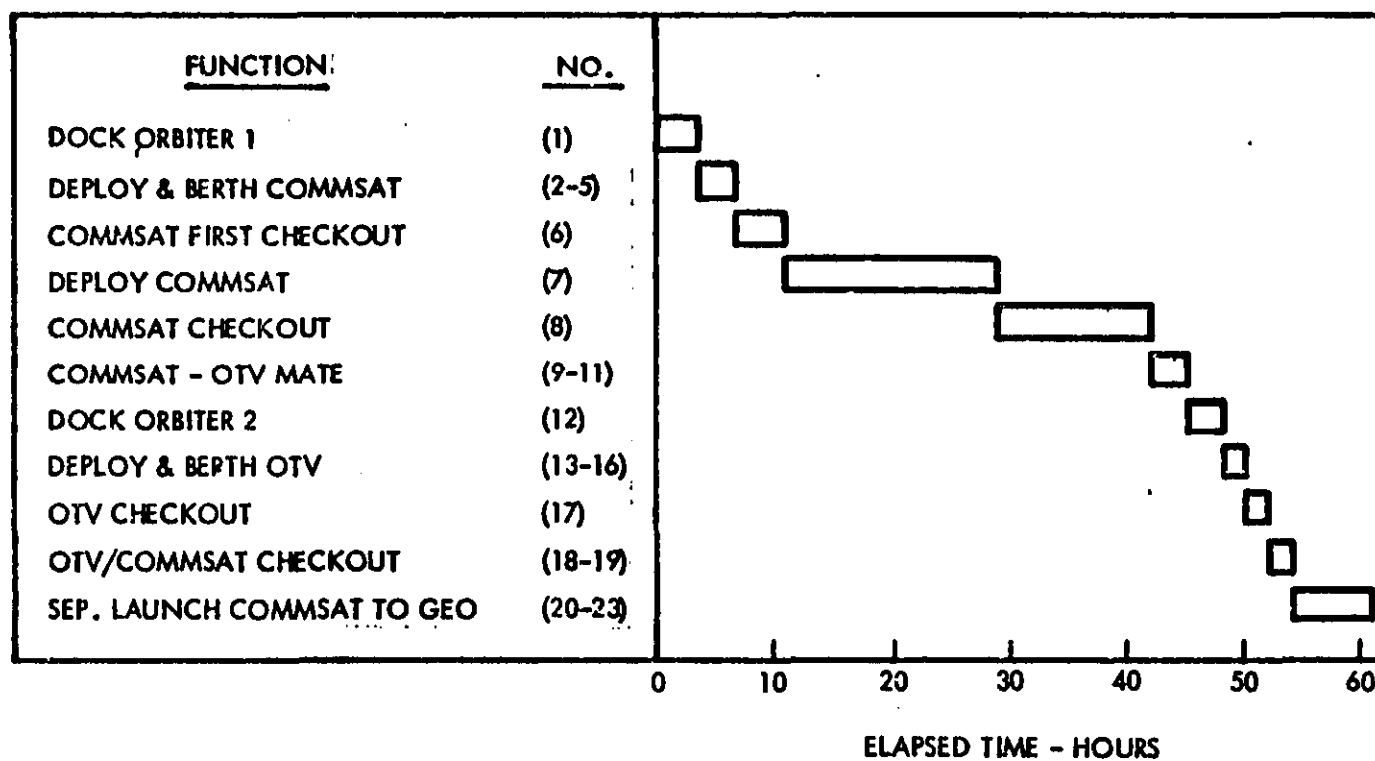


FIGURE C-3. CHECKOUT/SERVICING TIMELINE, COMM SAT AT ORBITER

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TABLE C-4. TIME RATIONALE - COMMUNICATION SATELLITE SERVICING AT SOC

TASK NO.	TASK DESCRIPTION	ELAPSED TIME (HR)	CREW QTY	MAN-HR	RATIONALE
1.0	DOCK ORBITER TO SOC	3.25	3.0	9.8	AVG. 1.75 HR, BASED ON DAYLIGHT DOCKING + UNLOAD FUEL (1.5 HR)
2.0	DEPLOY COMM SAT FROM PAYLOAD BAY	0.3	3.0	0.9	BASED ON SPAR SIM. DATA (RMS PREV. CHECKED)
3.0	MANEUVER COMM SAT TO SOC	0.8	3.0	2.4	SPAR SIM. DATA (ROEBUCK SOC WORK-BAY HANDBOOK)
4.0	BERTH COMM SAT TO SOC	0.2	3.0	0.6	RDF TEST SIMILARITY
5.0	MATE CHECKOUT UMBILICAL	0.5	5.0	2.5	LIKE OTV TIME
6.0	PRELIM. CHECKOUT OF COMM SAT	5.4	3.0	16.0	FROM TABLE A-5
7.0	DEPLOY COMM SAT APPENDAGES	18.2	2.1	70.9	"
8.0	CHECK OUT COMM SAT	12.8	2.8	37.6	"
9.0	SAFE COMM SAT	0.5	3.0	1.5	"
10.0	DEMATE COMM SAT UMBILICAL	0.5	3.0	1.5	ENGR. ESTIMATE
11.0	MANEUVER COMM SAT TO OTV	2.0	3.5	7.0	FROM TABLE A-5
12.0	DOCK ORBITER TO SOC	3.25	3.0	0.9	SAME AS 1.0 (INCL. UNLOAD FUEL)
13.0	DEPLOY OTV FROM PAYLOAD BAY	0.3	3.0	0.9	SEE 2.0
14.0	MANEUVER OTV TO SOC	0.8	3.0	2.4	SEE 3.0
15.0	BERTH OTV TO SOC FSF	0.2	3.0	0.6	SEE 4.0
16.0	MATE OTV UMBILICAL	0.5	5.0	2.5	SEE 5.0
17.0	CHECK OUT OTV	2.5	2.0	5.0	FROM TABLE A-5
18.0	MATE OTV & COMM SAT	1.0	3.0	3.0	"
19.0	CHECK OUT INTEGRATED SYSTEM	1.0	4.0	4.0	"
20.0	SUPPLY OTV WITH CONSUMABLES	1.5	3.0	4.5	"
21.0	DEMATE OTV UMBILICAL	1.0	3.0	3.0	"
22.0	SEPARATE INTEGRATED SYSTEM	1.5	3.0	4.5	"
23.0	LAUNCH TO GEO	3.0	3.0	9.0	"
TOTALS		61.0	73.4	199.6	
AVERAGE PER TASK		2.6	3.2	8.7	



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FIGURE C-4. CHECKOUT/SERVICING TIMELINE, COMM SAT AT SOC

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TABLE C-5. COMM SAT CHECKOUT/SERVICING (ENGINEERING ESTIMATE PER TASK)

TASK NO	TASK DESCRIPTION	ESTIMATED TIME (HRS)	PERCENT OF TASK	PERCENT OF TASK	PERCENT OF TASK	PERCENT OF TASK	PERCENT OF TASK	PERCENT OF TASK
1.1	INSPECT COMM SAT AT SOC	0.5	1.0	1.0	1.0	1.0	1.0	1.0
1.2	PLANNING AND CHECKOUT PREPARATION	0.5	1.0	1.0	1.0	1.0	1.0	1.0
1.3	CONFIRM SOC FOR CHECKOUT	0.5	1.0	1.0	1.0	1.0	1.0	1.0
1.4	SOC POWER FOR COMM SAT CHECKOUT	0.2	1.0	1.0	1.0	1.0	1.0	1.0
2.1	ACTIVATE COMMAND AND CONTROL	0.1	2.0	2.0	2.0	2.0	2.0	2.0
2.2	ACTIVATE THEORETICAL CONTROL	0.2	2.0	2.0	2.0	2.0	2.0	2.0
2.3	ACTIVATE THEORETICAL POSITION SYS	0.1	3.0	3.0	3.0	3.0	3.0	3.0
2.4	PERFORM ELECTRONICS TEST	0.5	3.0	3.0	3.0	3.0	3.0	3.0
2.5	BATTERY SYSTEM TEST	0.2	3.0	3.0	3.0	3.0	3.0	3.0
2.6	SOCAL ANALYST POSITIONING SYSTEM TEST	0.5	3.0	3.0	3.0	3.0	3.0	3.0
2.7	SATCOM TRANSMITTER CHECKOUT	0.5	3.0	3.0	3.0	3.0	3.0	3.0
2.8	SATCOM MAINTAIN SWITCH CHECKOUT	1.0	3.0	3.0	3.0	3.0	3.0	3.0
2.9	ANTENNA POINTING CHECKOUT	0.2	3.0	3.0	3.0	3.0	3.0	3.0
2.10	THEORETICAL CONTROL CHECKOUT	0.3	3.0	3.0	3.0	3.0	3.0	3.0
2.11	MAINT PROGRAMMING AND FULL CHECKOUT	0.5	3.0	3.0	3.0	3.0	3.0	3.0
2.12	ANTENNA CONTROL CHECKOUT	0.2	3.0	3.0	3.0	3.0	3.0	3.0
3.1	SECURE COMM SAT SYSTEMS	0.5	3.0	3.0	3.0	3.0	3.0	3.0
3.2	POWER DOWN COMM SAT	0.2	3.0	3.0	3.0	3.0	3.0	3.0
3.3	REPLENISH PREPARATION	0.5	3.0	3.0	3.0	3.0	3.0	3.0
3.4	SOC DEPLOYMENT CONFIGURATION	0.5	3.0	3.0	3.0	3.0	3.0	3.0
4.1	DEPLOY STRUCTURE (SOLAR)	1.0	3.0	3.0	3.0	3.0	3.0	3.0
4.2	DEPLOY ANTENNAS	2.0	3.0	3.0	3.0	3.0	3.0	3.0
4.3	SECURE DEPLOYMENT SYSTEM	0.5	3.0	3.0	3.0	3.0	3.0	3.0
4.4	TRAIN SOC ATTITUDE-CONTROL	0.5	3.0	3.0	3.0	3.0	3.0	3.0
4.5	COMM SAT TO INTERNAL POWER	0.3	3.0	3.0	3.0	3.0	3.0	3.0
4.6	ACTIVATE-ORBIT THEORETICAL CONTROL	0.5	3.0	3.0	3.0	3.0	3.0	3.0
4.7	ELECTRONIC POWER SYSTEM CHECKOUT	2.5	3.0	3.0	3.0	3.0	3.0	3.0
4.8	ANTENNA CONTROL CHECKOUT	0.5	3.0	3.0	3.0	3.0	3.0	3.0
4.9	PROPULSION SYSTEM CHECKOUT	1.0	3.0	3.0	3.0	3.0	3.0	3.0
4.10	COMMUNICATIONS SYSTEMS POWER-UP	0.5	3.0	3.0	3.0	3.0	3.0	3.0
4.11	ANTENNA ALIGNMENT	4.0	3.0	3.0	3.0	3.0	3.0	3.0
4.12	TRANSMITTER RECEIPT/TRANSMIT CHECKOUT	2.5	3.0	3.0	3.0	3.0	3.0	3.0
4.13	TRANS. SWITCH CHECKOUT	1.0	3.0	3.0	3.0	3.0	3.0	3.0
4.14	COMM SAT POWER-DOWN	0.5	3.0	3.0	3.0	3.0	3.0	3.0
4.15	NOTE AND VERIFY OTV INTERFACE	1.5	3.0	3.0	3.0	3.0	3.0	3.0
5.1	TRAIN SOC-OTV/COMM SAT	0.5	3.0	3.0	3.0	3.0	3.0	3.0
5.2	FUEL SERVICE PREPARATION	0.5	3.0	3.0	3.0	3.0	3.0	3.0
5.3	OTV/COMM SAT-FUEL SERVICE	1.0	3.0	3.0	3.0	3.0	3.0	3.0
5.4	COMM SAT/OTV TEST FIRING PREPARATION	0.5	3.0	3.0	3.0	3.0	3.0	3.0
5.5	TEST FIRING—COMM SAT/OTV	0.3	3.0	3.0	3.0	3.0	3.0	3.0
6.1	COMM SAT/OTV SEPARATION PREPARATION	0.5	3.0	3.0	3.0	3.0	3.0	3.0
6.2	SEPARATE COMM SAT/OTV FROM SOC	0.3	3.0	3.0	3.0	3.0	3.0	3.0
6.3	COMM SAT/OTV STANDSTILL—SOC	0.5	3.0	3.0	3.0	3.0	3.0	3.0
6.4	TRAIN SOC AFTER COMM SAT SEPARATION	1.0	3.0	3.0	3.0	3.0	3.0	3.0
6.5	GEN TRANSPORT PREPARATION	1.0	3.0	3.0	3.0	3.0	3.0	3.0
6.6	MAINT ENGINE HOT CHECKOUT	0.5	3.0	3.0	3.0	3.0	3.0	3.0
6.7	GEN TRANSPORT PREPARATION	0.5	3.0	3.0	3.0	3.0	3.0	3.0
6.8	COMM SAT READY FOR GEN TRANSPORT	0.3	3.0	3.0	3.0	3.0	3.0	3.0
6.9	TOTALS	65.0	100	100	100	100	100	100
7.1	AVERAGE CHECKOUT TIME = $\frac{65.0}{25} = 2.60$							
7.2	AVERAGE PERCENT OF TASK = $\frac{154.7}{25} = 6.19$							

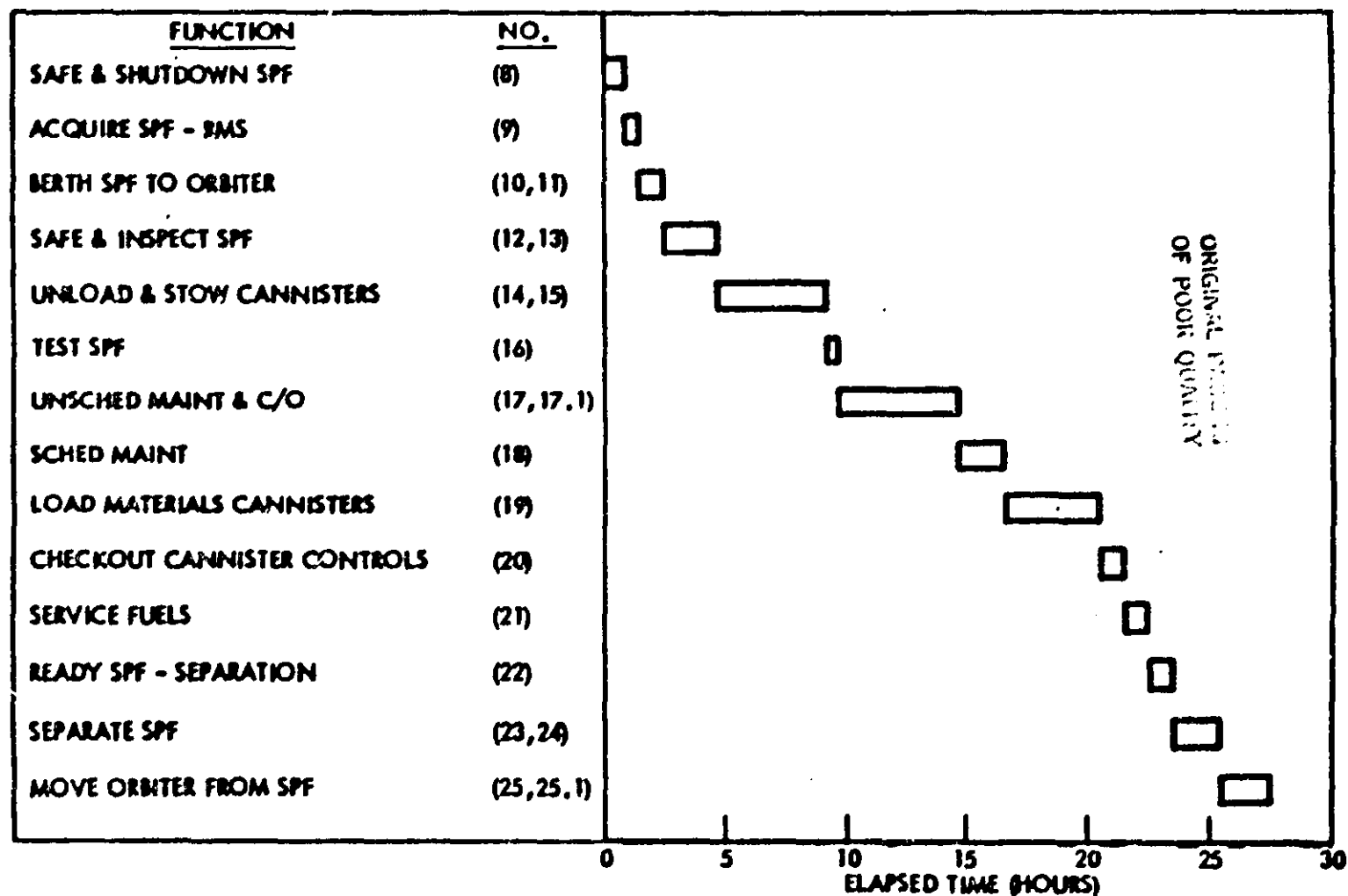


FIGURE C-5. CHECKOUT/SERVICING TIMELINE,
SPACE PROCESSING FACILITY AT ORBITER

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C-15

TABLE C-6. TIME RATIONALE - SPACE PROCESSING TURNAROUND OPERATIONS
AT ORBITER

TASK NO.	TASK DESCRIPTION	ELAPSED TIME (HR)	CREW QTY	MAN-HR	RATIONALE
8.0	SAFE & SHUT DOWN SPF	1.0	3	3.0	THE ORBITER HAS APPROACHED THE SPF MAINTAINING A SAFE DISTANCE USING THE COMMAND LINK. THE ORBITER COMMANDS THE SPF TO THE APPROPRIATE BERTHING POSITION. ORBITER COMMAND & CONTROL PLACES ALL SPF SYSTEMS IN A SAFE OR SHUTDOWN CONDITION (CREW REQUIRED—A, B, C). ^a
9.0	ACQUIRE SPF	0.5	3	1.5	USE THE DEPLOYED ORBITER RMS AND ACQUIRE THE SPF. MOVE THE SPF WITHIN CLOSE PROXIMITY OF THE ORBITER BERTHING POSITION (CREW REQUIRED—C, B, D).
10.0, 11.0	BERTH SPF TO ORBITER	1.0	3	3.0	USE THE RMS TO BERTH THE SPF TO THE ORBITER. IN LIKE MANNER, MAKE ALL ELECTRICAL & FLUID CONNECTIONS. LOCK ALL MATING INTERFACES WITH THE RMS (CREW REQ'D—B, C, D).
12.0, 13.0	SAFE AND INSPECT SPF	2.0	4	8.0	SAFE OR POWER DOWN ALL ELEC. & FLUID SUBSYSTEMS. USE VISUAL & REMOTE AIDS TO INSPECT THE SPF (CREW REQUIRED—C, B, 2D).
14.0, 15.0	UNLOAD AND STOW MATERIALS CANISTERS	4.0	4	16.0	POSITION THE CANISTER HANDLING FIXTURE TO THE UNLOADING LOCATION. USE THE RMS TO UNLOAD THE FOUR MATERIALS CANISTERS ONTO THE HANDLING FIXTURE. STOW FIXTURE AND CANISTERS IN ORBITER (CREW REQUIRED—B, C, 2D).
16.0	TEST SPF	1.0	4	4.0	APPLY ORBITER PWR TO SPF. PWR UP ALL SPF SYSTEMS. USE BUILT-IN TEST & ORBITER C/O SYSTEM TO PERFORM C/O OF ALL SPF SYSTEMS. USE ORBITER FAULT ISOLATION ROUTINES TO ISOLATE DEFECTIVE SYSTEMS OR COMPONENTS. IDENTIFY DEFECTIVE HARDWARE FOR REPAIR. POWER DOWN AND SAFE ALL SYSTEMS FOR MAINTENANCE ACTIVITY (CREW REQUIRED—A, B, C, D).
17.0	UNSCHEDULED MAINTENANCE	5.0	4	20.0	TWO HARDWARE SYST. FAILURES ARE PREDICTED BASED ON A 25-HR MISSION. REMOVE & REPLACE TWO DEFECTIVE LRU's USING THE RMS AT 2 HR EACH. TEST TIME FOLLOWING CORRECTIVE MAINTENANCE IS 0.5 HR EACH (CREW REQUIRED—B, C, 2D).
17.1	CHECKOUT	1.0	4	4.0	POWER UP ALL SYSTEMS USING ORBITER POWER; USE SPF BUILT-IN TEST & ORBITER C/O EQUIP. TO CONFIRM SUCCESSFUL OPERATION OF ALL SPF SYSTEMS. POWER DOWN OR SAFE ALL SYSTEMS AT CONCLUSION OF CHECKOUT (CREW REQUIRED—A, B, C, D).
19.0	LOAD MATERIALS CANISTERS ONTO SPF	4.0	4	16.0	POSITION MATERIALS HANDLING FIXTURE WITH LOADED CANISTERS ON LOADING AREA; LOAD CANISTERS ON SPF USING RMS; CLOSE OUT CANISTERS; STOW FIXTURE IN ORBITER STORAGE AREA (CREW REQUIRED—A, B, C, D).

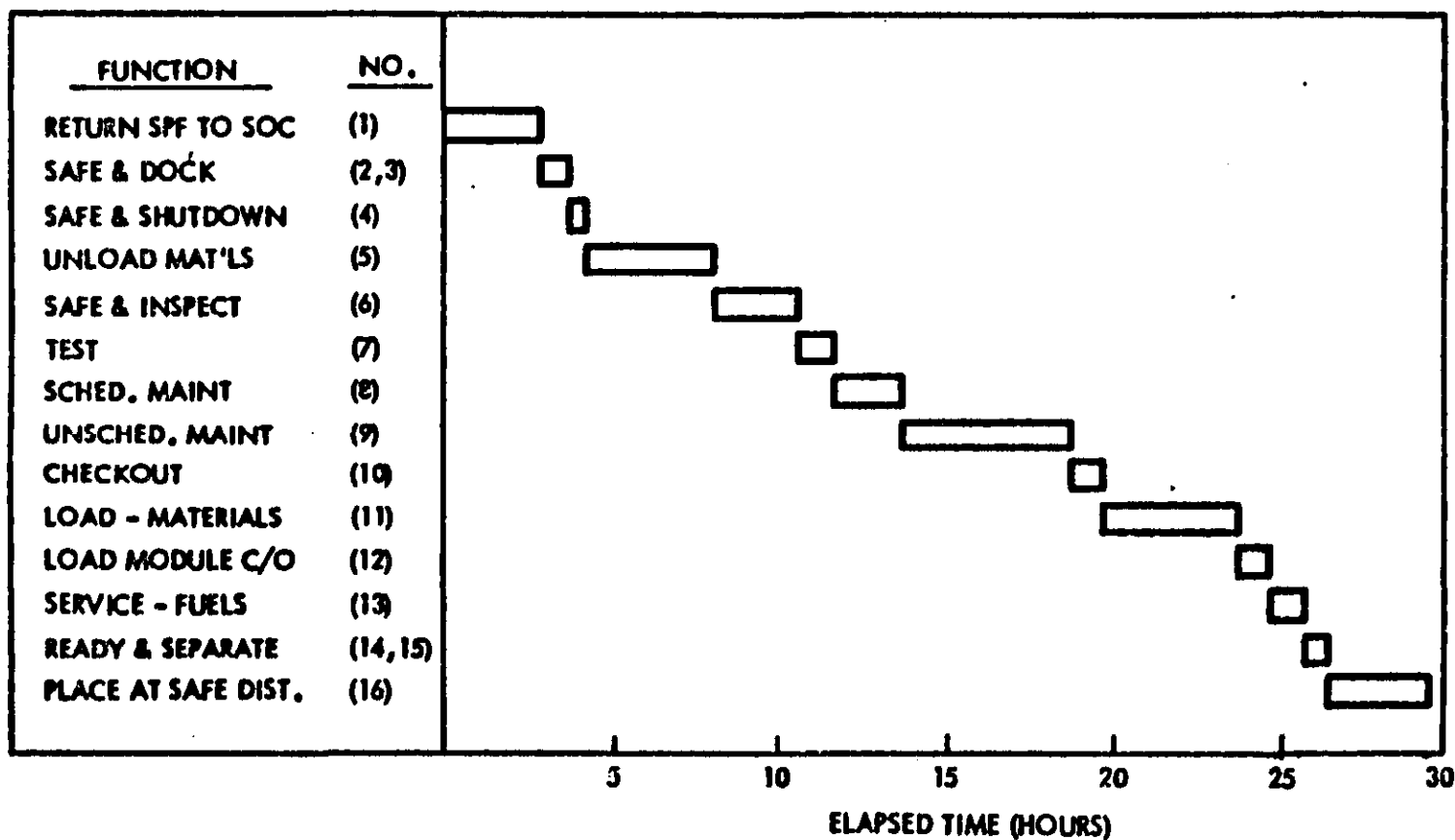
*CODES FOR CREW REQUIREMENTS ARE GIVEN AT END OF THIS TABLE.

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TABLE C-6. TIME RATIONALE - SPACE PROCESSING TURNAROUND OPERATIONS
AT ORBITER (CONT.)

TASK NO.	TASK DESCRIPTION	ELAPSED TIME (HR)	CREW QTY	MAN-HR	RATIONALE
20.0	CHECKOUT—MATERIALS PROCESSING CONTROLS	1.0	3	3.0	APPLY ORBITER POWER TO SPF. ACTIVATE SPF-ORBITER CHECKOUT SYSTEM; ACTIVATE SPF MATERIALS PROCESSING CONTROLS; PERFORM FUNCTIONAL TESTS OF ALL COMMAND AND CONTROL FUNCTIONS. POWER DOWN OR SAFE ALL SYSTEMS (CREW REQ'D—A, B, C).
21.0	SERVICE FUELS	1.0	4	4.0	ACTIVATE SPF SERVICING SYSTEM; VERIFY SERVICE CONNECTIONS VALID; PLACE ORBITER SERVICING SYSTEM IN READY; INITIATE FLUID TRANSFER TO SPF; COMPLETE SERVICING OPERATION; PLACE ALL SPF SYSTEMS IN SAFE (CREW REQ'D—A, B, C, D).
22.0	READY SPF FOR SEPARATION FROM ORBITER	1.0	4	4.0	VERIFY ALL SPF SYSTEMS IN SAFE OR POWERED-DOWN MODE; REMOVE ORBITER POWER FROM SPF; INITIATE SPF POWER SYSTEM; SAFE OR SHUT DOWN ALL SPF SYSTEMS; USE RMS TO REMOVE ALL UNBILICALS; STOW UNBILICALS (CREW REQ'D—A, B, C, D).
23.0, 24.0	SEPARATE SPF FROM ORBITER	2.0	4	8.0	USE THE RMS TO DEPART THE SPF FROM THE ORBITER. MANEUVER THE SPF WITH THE RMS TO A SAFE DISTANCE FROM THE ORBITER. ORIENT SPF TO APPROPRIATE FREE-FLIGHT ATTITUDE. REMOVE RMS FROM SPF; STOW RMS IN ORBITER (CREW REQ'D—A, B, C, D).
25.0	MOVE ORBITER FROM SPF	2.0	2	4.0	INITIATE ORBITER ACS AND MOVE ORBITER A SAFE DISTANCE FROM SPF. INITIATE SPF SPACE PROCESSING SYSTEMS AND VERIFY PROPER OPERATION USING ORBITER COMMAND & CONTROL. USING MAIN PROPULSION OR ACS, MOVE ORBITER TO PARKING ORBIT (CREW REQUIRED—B, C).
25.1	STOW AND SECURE RMS	0.5	3	1.5	STOW AND SECURE RMS IN ORBITER IN PREPARATION FOR EARTH RETURN (CREW REQUIRED—A, B, C)
NOTES 1. CREW CODES (ORBITER) A—PILOT (COMMANDER) B—CO-PILOT (SAFETY) C—SPF DIRECTOR D—SPECIALIST 2. ALL ELAPSED TIMES DEVELOPED ARE BASED ON ENGINEERING ESTIMATES OF TIMES REQUIRED TO ACCOMPLISH EACH DETAILED TASK.					

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FIGURE C-6. CHECKOUT/SERVICING TIMELINE,
SPACE PROCESSING FACILITY TURNAROUND OPERATIONS AT SOC

TABLE C-7. TIME RATIONALE - SPF TURNAROUND OPERATIONS WITH SOC

TASK NO.	TASK DESCRIPTION	ELAPSED TIME (HR)	CREW QTY	MAN-HOURS	RATIONALE
1.0	SPF RETURN TO SOC	3.0	3	9.0	REMOTE OPERATION
2.0	SAFE SPF	0.5	3	1.5	
3.0	RETRIEVE SPF	0.5	4	2.0	
4.0	BERTH TO FSF	0.5	4	2.0	SPF DOCK TO SOC
5.0	MATE UMBILICALS	0.5	4	2.0	BERTH TO FSF WITH RMS
6.0	SAFE & SHUT DOWN SPF	0.5	3	1.5	CONNECT UMBILICALS
7.0	INSPECT SPF	1.0	4	4.0	PRELIMINARY INSPECTION
8.0, 9.0	UNLOAD & STOW CANISTERS	4.0	4	16.0	
10.0	INSPECT & CHECK OUT SPF	2.5	4	10.0	
11.0	UNSCHED. MAINTENANCE-REPAIR	5.0	3	15.0	PROCESSING CANISTERS
11.1	SPF CHECKOUT	1.0	4	4.0	FAULT ISOLATION
12.0	SCHEDULED MAINTENANCE	2.0	3	6.0	25-HR MISSION, 2 FAILURES
13.0	LOAD MATERIALS CANISTERS	4.0	4	16.0	MAINT. VERIFICATION
14.0	CHECKOUT—CANISTERS	1.0	3	3.0	ADJUST, ALIGN, ETC.
15.0	RESUPPLY CONSUMABLES	1.0	4	4.0	FOUR MODULES
16.0	PREPARATION FOR SEPARATION	0.5	3	1.5	CHECK OUT FOUR MODULES
17.0	SEPARATE SPF FROM SOC	0.3	4	1.2	SERVICE FUELS
18.0	SPF TO FREE ORBIT	3.0	3	9.0	SEP. UMBILICALS, ETC.
	TOTAL	31.0	64	108.0	USE RMS
	AVERAGE PER TASK	1.7	3.5	6.0	SOC MONITOR & CONTROL

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TABLE C-8. TYPICAL ON-ORBIT CHECKOUT/SERVICING OPERATIONS ESTIMATION
GUIDELINES (APPLICABLE TO OTV, SATELLITES, SPACE PROCESSING FACILITY, ETC.)

ACTIVITY	TASK TIME (HOURS)	CREW REQUIRED QUANTITY	MAN-HOURS	REMARKS
RETURN TO SOC VICINITY READY TO DOCK	3.0-4.0	3-4 (A+C+D)	9.0-16.0	MOVE 1 MILE—0.5 FT/SEC RETURN OR DEPART SOC (LARGER NUMBERS FOR OTV)
SAFE THE UNIT	0.5	3 (A+C+D)	1.5	
INSPECT THE UNIT	2.0	4 (A+C+D+E)	8.0	DIRECT & REMOTE VISUAL
DOCKING OR SEPARATION	0.3	4 (A+C+D+E)	1.2	MANIPULATOR IS USED
TEST OR CHECKOUT	1.0	4 (A+C+D+E)	4.0	END TO END; POWER UP & SHUT DOWN
SERVICE FLUIDS	1.0	4 (A+C+D+E)	4.0	SETUP & TEARDOWN—0.5 HR FUEL—0.5 HR
UNSCHEDULED MAINTENANCE REPAIR—PER FAILURE	2.0 } 0.5 } 2.5	R&R 3 (C+D+E) C/O 4 (A+C+D+E)	6.0 } 2.0 } 8.0	REMOVE & REPLACE (REMOTE) CHECKOUT (SUBSYSTEM)
CREW CODES A—SOC COMMANDER B—LIFE SUPPORT DIRECTOR C—PROGRAM DIRECTOR D—SAFETY & MAINTENANCE E—SPECIALIST • MANIPULATOR • TEST • FUEL SERVICE				

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TABLE C-9. TYPICAL RMS FUNCTION TIME FROM SPAR STUDIES

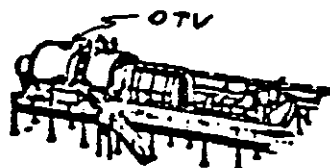
FUNCTION	TIME	
	MINUTES	HOURS
UNCRADLE AND CHECK OUT ARM	60	1.0
DEPLOYMENT (32 KLB)		
• MANEUVER TO GRAPPLE PAYLOAD	15	0.25
• DEPLOY FROM GUIDES	5	0.08
• MANEUVER TO RELEASE POSITION	20	0.33
RETRIEVAL (32 KLB)		
• TRACK & CAPTURE (TERMINAL PHASE)	15	0.25
• MANEUVER TO GUIDES	15	0.25
• BERTH PAYLOAD	5	0.08
• STOW RMS	15	0.25
<p><i>Source: Middleton, J.A., Considerations for Payload Manipulation, in: Proceedings, RMS Users' Conference, Skyline Hotel, Toronto, Canada, 5-7 May 1981.</i></p>		

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APPENDIX D

COST ANALYSIS SHEETS

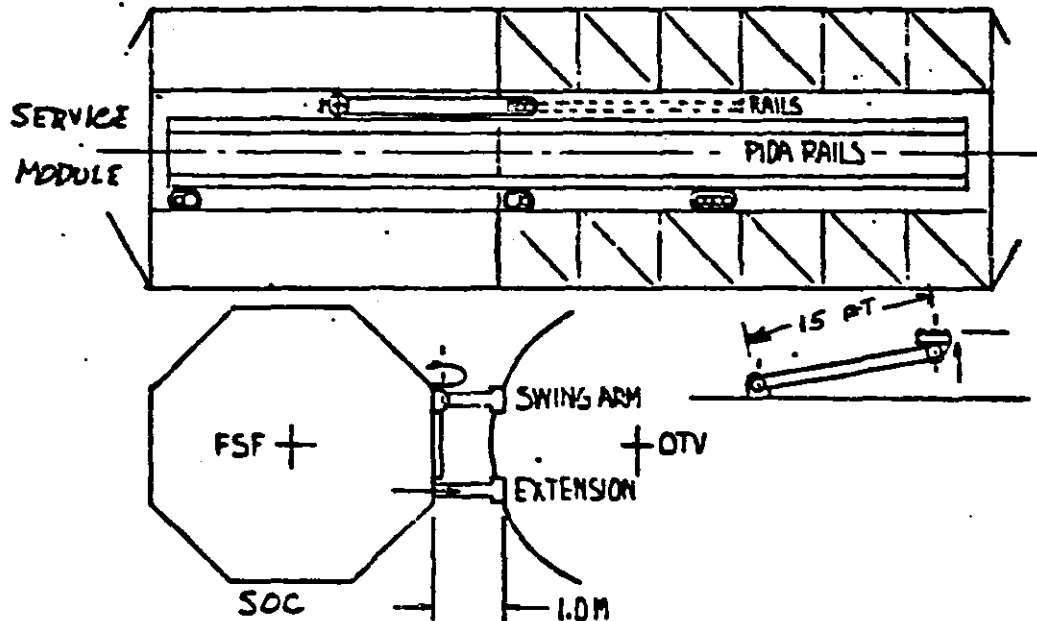
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COST ANALYSIS SHEET			
ITEM OR FUNCTION OTV SERVICE FIXTURE WITH SERVICE CONNECTION		PAGE REF. NO.	1 OF 3
PROJECT/SYSTEM OTV—GROUND SERVICING		WBS NO.	
ACTIVITY SERVICE & C/O OTV		NO.	FLOW CHART 12.0
DESCRIPTION/SPECIFICATION/DESIGN SERVICE FIXTURE TO SURROUND OTV AS SHOWN TO PROVIDE ACCESS TO ALL AREAS IN NEED OF SERVICE—MUST HAVE TWO UMBILICAL ARMS SIMILAR TO SOC SERVICING CONCEPT (SEE SHEET 2)		 <p>OTV</p> <p>PAYLOAD OPERATIONS</p> <p>DDT&E \$ = M TFU</p>	
TOTAL MASS (KG)		5000	
STRUCTURAL MASS (KG) 3.992		3980	3.088
MECHANISMS MASS (KG) 8.028		1020	(see p. 2) 8.904
ELECTRICAL/PD MASS (KG)			
ELECTRONIC MASS (KG)			
REQUIRED QUANTITY		1	
COMMENTS (DDT&E OR TECHNOLOGY STATUS)			
TYPICAL FIXTURE		\$ 12.020	\$ 11.992
CER's/FACTORS			
SIMILAR TO AIRCRAFT SERVICING FIXTURE			

COST ANALYSIS SHEET																											
ITEM OR FUNCTION UMBILICAL ARMS ON OTV SERVICE FIXTURE	PAGE REF. NO.	2 OF 3																									
PROJECT/SYSTEM OTV—GROUND SERVICING	WBS NO.																										
ACTIVITY SERVICE & C/O OTV	NO.	FLOW CHART 12.0																									
DESCRIPTION/SPECIFICATION/DESIGN OTV SERVICING FIXTURE MUST BE EQUIPPED WITH TWO UMBILICAL ARMS SIMILAR TO THOSE USED IN SOC FLIGHT SUPPORT FACILITY. SEE ATTACHMENT FOR CONCEPT																											
<div style="display: flex; justify-content: space-between;"> <u>DDT&E</u> <u>\$ - M</u> <u>RECURRING</u> </div>																											
<table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 40%;">TOTAL MASS</td> <td style="width: 10%;">(KG)</td> <td style="width: 10%; text-align: right;">510</td> <td style="width: 40%;"></td> </tr> <tr> <td>STRUCTURAL MASS</td> <td>(KG) 0.477</td> <td style="text-align: right;">180</td> <td style="text-align: right;">0.50</td> </tr> <tr> <td>MECHANISMS MASS</td> <td>(KG) 3.769</td> <td style="text-align: right;">280</td> <td style="text-align: right;">6.619</td> </tr> <tr> <td>ELECTRICAL/PD MASS</td> <td>(KG)</td> <td style="text-align: right;"></td> <td></td> </tr> <tr> <td>ELECTRONIC MASS</td> <td>(KG) } 0.372</td> <td style="text-align: right;">50</td> <td style="text-align: right;">0.810</td> </tr> <tr> <td>REQUIRED QUANTITY</td> <td></td> <td style="text-align: right;">2</td> <td></td> </tr> </table>				TOTAL MASS	(KG)	510		STRUCTURAL MASS	(KG) 0.477	180	0.50	MECHANISMS MASS	(KG) 3.769	280	6.619	ELECTRICAL/PD MASS	(KG)			ELECTRONIC MASS	(KG) } 0.372	50	0.810	REQUIRED QUANTITY		2	
TOTAL MASS	(KG)	510																									
STRUCTURAL MASS	(KG) 0.477	180	0.50																								
MECHANISMS MASS	(KG) 3.769	280	6.619																								
ELECTRICAL/PD MASS	(KG)																										
ELECTRONIC MASS	(KG) } 0.372	50	0.810																								
REQUIRED QUANTITY		2																									
COMMENTS (DDT&E OR TECHNOLOGY STATUS) <div style="display: flex; justify-content: space-between; margin-top: 10px;"> \$ 4.618 \$ 7.929 </div> <div style="text-align: center; margin-top: 20px;"> ORIGINAL PAGE IS OF POOR QUALITY </div>																											
CER's/FACTORS																											

SERVICING ACTIVITY DATA

FUNCTION ITEM	2.2 Mate OTV/ QSE	ATTACHMENT	
METHOD		PAGE	3 of 3
SUBJECT Payload Fixture Requirements			



The payload fixture must duplicate the umbilical connections to be used in space (SOC) to verify the alignment and attachment functions (pull-in, QD leakage, etc.)

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COST ANALYSIS SHEET			
ITEM OR FUNCTION OTV FLUIDS INTERFACE ON ORBITER		PAGE 1	OF 1
		REF. NO.	
PROJECT/SYSTEM OTV—GROUND SERVICING		WBS NO.	
ACTIVITY LOADING CRYOGENICS AND OTHER PROPELLANTS AND FLUIDS		NO.	25.0
DESCRIPTION/SPECIFICATION/DESIGN CRYOGENICS AND OTHER CONSUMABLES WILL BE LOADED ON OTV WHILE OTV IS IN ORBITER PAYLOAD BAY ON THE LAUNCH PAD. FLUID INTERFACES BETWEEN GSE AND ORBITER AND BETWEEN ORBITER AND OTV AND ASSOCIATED LINES ARE NEEDED. INTERFACES WILL BE QUICK CONNECTS/DISCONNECTS (LO ₂ , LH ₂ , He, N ₂ , HYDRAZINE).			
		<u>DDT&E</u>	<u>\$ = H</u> <u>RECURRING</u>
TOTAL MASS (KG)		<u>110</u>	
STRUCTURAL MASS (KG) 0.708		<u>50</u>	0.711
MECHANISMS MASS (KG) 1.531		<u>60</u>	2.035
ELECTRICAL/PD MASS (KG)		} SEE NEXT SHEET	
ELECTRONIC MASS (KG)			
REQUIRED QUANTITY		<u>2</u>	LO ₂ & LH ₂
COMMENTS (DDT&E OR TECHNOLOGY STATUS)			
		\$ 2.239	\$ 2.746
CER'S/FACTORS			

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COST ANALYSIS SHEET			
ITEM OR FUNCTION OTV ELECTRICAL INTERFACE ON ORBITER		PAGE	1 OF 1
		REF. NO.	
PROJECT/SYSTEM OTV—GROUND SERVICING		WBS NO.	
ACTIVITY MONITOR OTV & LOADING OF FLUIDS ON OTV		NO.	25.0
DESCRIPTION/SPECIFICATION/DESIGN			
AN ELECTRICAL INTERFACE SIMILAR TO THE FLUID INTERFACE WOULD BE REQUIRED TO OPERATE FUEL LOADING SYSTEM & MONITOR HEALTH & STATUS OF OTV.			
		<u>DDT&E</u>	<u>\$ = M</u> <u>TFU</u>
TOTAL MASS	(KG)	<u>50.0</u>	
STRUCTURAL MASS	(KG) 0.263	<u>20.0</u>	0.143
MECHANISMS MASS	(KG) 0.385	<u>10.0</u>	0.222
ELECTRICAL/PD MASS	(KG)	<u> </u>	
ELECTRONIC MASS	(KG) 1.456	<u>20.0</u>	0.299
REQUIRED QUANTITY		<u>1</u>	
COMMENTS (DDT&E OR TECHNOLOGY STATUS)			
		\$ 2.104	\$ 0.664
CER's/FACTORS			

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COST ANALYSIS SHEET			
ITEM OR FUNCTION		PAGE	1 OF 1
OTV CONTROL & MONITOR STATION ON ORBITER		REF. NO.	
PROJECT/SYSTEM		WBS NO.	
OTV—GROUND SERVICING		NO.	5.0, 6.0
ACTIVITY			
MONITOR HEALTH & STATUS OF OTV			
DESCRIPTION/SPECIFICATION/DESIGN			
RETRIEVAL OF OTV & STOWAGE IN PAYLOAD BAY PRIOR TO RETURN TO EARTH WILL REQUIRE THIS SERVICE. OTV SERVICE PANEL WILL BE IN AFT FLIGHT DECK.			
	<u>DDT&E</u>	<u>\$ = M</u>	<u>TFU</u>
TOTAL MASS	(KG)	1000	
STRUCTURAL MASS	(KG) 3.586	900	2.970
MECHANISMS MASS	(KG)		
ELECTRICAL/PD MASS	(KG)		
ELECTRONIC MASS	(KG) 1.076	200	1.170
REQUIRED QUANTITY		1	
COMMENTS (DDT&E OR TECHNOLOGY STATUS)			
	\$4.662		\$4.140
CER'S/FACTORS			

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COST ANALYSIS SHEET																				
ITEM OR FUNCTION OTV CONTROL & MONITOR STATION ON SOC (SOFTWARE AND ITS STORAGE ONLY)	PAGE	1 OF 1																		
	REF. NO.																			
PROJECT/SYSTEM OTV—SOC SERVICING	LBS NO.																			
ACTIVITY SERVICING & C/O OF OTV	NO.	1.0 THROUGH 14.0																		
DESCRIPTION/SPECIFICATION/DESIGN CONTROL STATION & COMPUTERS WOULD BE STANDARD EQUIPMENT ON BOARD, BUT DEDICATED OTV SERVICING SOFTWARE WOULD BE REQUIRED.																				
<table border="0"> <tr> <td>TOTAL MASS</td> <td>(KG)</td> <td>10</td> </tr> <tr> <td>STRUCTURAL MASS</td> <td>(KG)</td> <td>_____</td> </tr> <tr> <td>MECHANISMS MASS</td> <td>(KG)</td> <td>_____</td> </tr> <tr> <td>ELECTRICAL/PD MASS</td> <td>(KG)</td> <td>_____</td> </tr> <tr> <td>ELECTRONIC MASS</td> <td>(KG)</td> <td>_____</td> </tr> <tr> <td>REQUIRED QUANTITY</td> <td></td> <td>_____</td> </tr> </table>			TOTAL MASS	(KG)	10	STRUCTURAL MASS	(KG)	_____	MECHANISMS MASS	(KG)	_____	ELECTRICAL/PD MASS	(KG)	_____	ELECTRONIC MASS	(KG)	_____	REQUIRED QUANTITY		_____
TOTAL MASS	(KG)	10																		
STRUCTURAL MASS	(KG)	_____																		
MECHANISMS MASS	(KG)	_____																		
ELECTRICAL/PD MASS	(KG)	_____																		
ELECTRONIC MASS	(KG)	_____																		
REQUIRED QUANTITY		_____																		
COMMENTS (DDT&E OR TECHNOLOGY STATUS) <div style="text-align: right;">\$1,000,000</div>																				
CER's/FACTORS																				

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COST ANALYSIS SHEET			
ITEM OR FUNCTION EXTENDABLE NON-PROPULSIVE BOOM		PAGE	1 OF 2
		REF. NO.	
PROJECT/SYSTEM OTV—SOC SERVICING		WBS NO.	
ACTIVITY PURGING & VENTING OTV		NO.	7.0
DESCRIPTION/SPECIFICATION/DESIGN BOOM REQUIRED TO AVOID CONTAMINANTS FROM PURGE GASES. SEE ATTACHMENT.			
		<u>DDT&E</u>	<u>\$ - M</u> <u>TFU</u>
TOTAL MASS (KG)		<u>41</u>	
STRUCTURAL MASS (KG) 0.263		<u>20</u>	0.143
MECHANISMS MASS (KG) 0.655		<u>20</u>	0.399
ELECTRICAL/PD MASS (KG)		<u> </u>	
ELECTRONIC MASS (KG) 0.019		<u>1</u>	0.020
REQUIRED QUANTITY		<u>1</u>	
COMMENTS (DDT&E OR TECHNOLOGY STATUS)			
		\$0.937	\$0.562
CER'S/FACTORS			

SERVICING ACTIVITY DATA

FUNCTION ITEM	6.0 Safe & Checkout OTV	ATTACHMENT	
METHOD		PAGE	2 of 2
SUBJECT SOC Requirements			

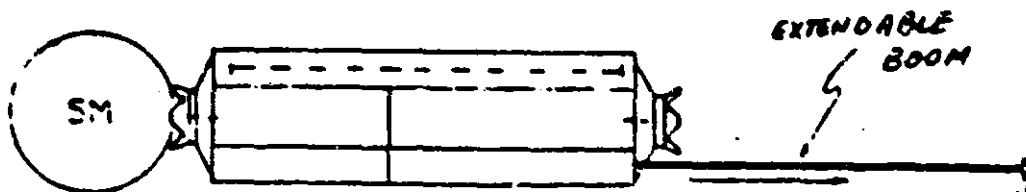


FIG 1

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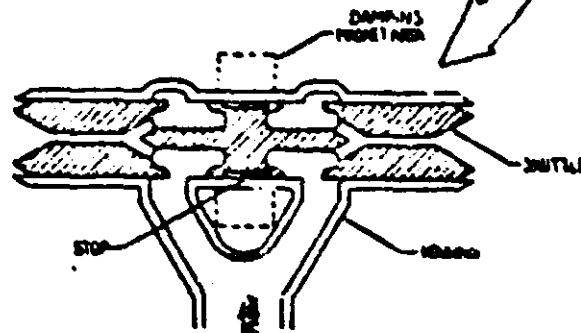


FIG 2

An expulsion system for purge & vent of OTV expendables tanks -

Figure 1. An expulsion arm, extendible from the service fixture to transmit overboard gasses away from the SOC to minimize or prevent contamination.

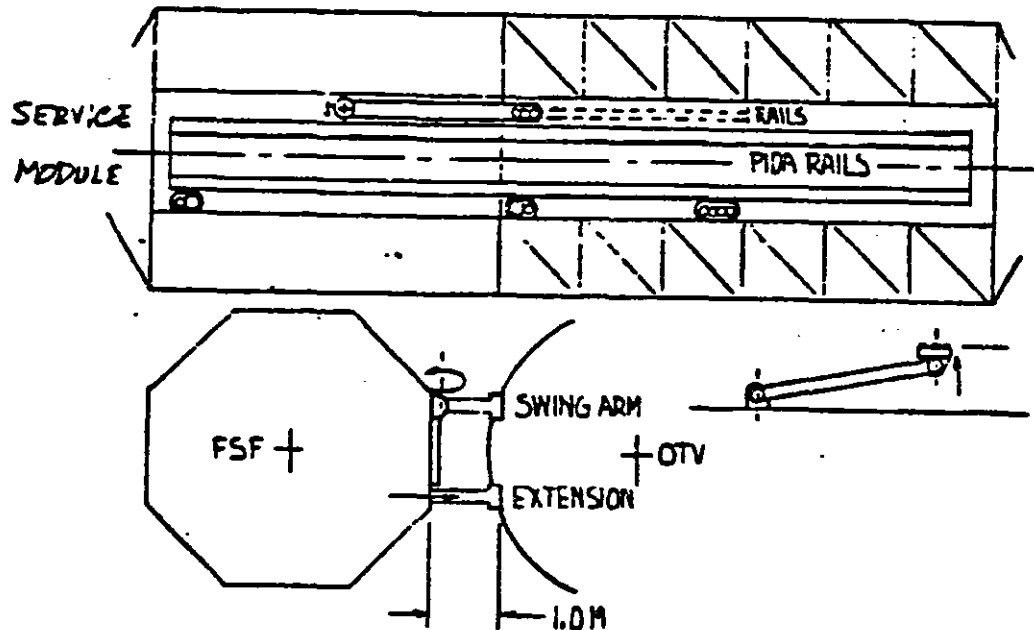
Figure 2. An non-reactive jet to minimize or prevent reaction forces against the SOC assembly.

Out board ends of free-floating shuttle absorb all reaction forces such that the input orifices meter the flow of gasses. To center the shuttle at a location resulting in a balanced reaction.

COST ANALYSIS SHEET			
ITEM OR FUNCTION RETRACTABLE UMBILICALS	PAGE	1 OF 2	
	REF. NO.		
PROJECT/SYSTEM OTV—SOC SERVICING	WBS NO.		
ACTIVITY RESUPPLYING CONSUMABLES	NO.	5.0 & 13.0	
DESCRIPTION/SPECIFICATION/DESIGN SEE ATTACHMENT FOR CONCEPT. UMBILICAL ARM WOULD BE STANDARD EQUIPMENT ON FLIGHT SUPPORT FACILITY, BUT DOES NOT NORMALLY INCLUDE CRYOGENIC DISCONNECT.			
	<u>DDT&E</u>	<u>\$ - H</u>	<u>RECURRING</u>
TOTAL MASS (KG)	510		
STRUCTURAL MASS (KG) 0.477	180		0.500
MECHANISMS MASS (KG) 3.769	280		6.619
ELECTRICAL/PD MASS (KG)			
ELECTRONIC MASS (KG) 0.372	50		0.810
REQUIRED QUANTITY	2		LO ₂ & LH ₂
COMMENTS (DDT&E OR TECHNOLOGY STATUS) <div style="display: flex; justify-content: space-between;"> \$4.618 \$7.929 </div> COSTS OF LO ₂ & LH ₂ DISCONNECTS ARE ONLY RELATIVE INPUTS THAT ARE REQUIRED IN THIS ITEM.			
CER'S/FACTORS <div style="text-align: center;">ORIGINAL PAGE 13 OF POOR QUALITY</div>			

SERVICING ACTIVITY DATA

FUNCTION ITEM	5.0 Mate OTV Umbilicals	ATTACHMENT	
METHOD		PAGE	2 of 2
SUBJECT SOC Requirements			



Four umbilical sets on the service fixture between the pida rails and the FSF corner.

The LH₂ umbilical in the storage deck area, the lox umbilical and the GN₂ acts and he umbilicals in the tankage area are fixed in location to mate with the OTV at the servicing station. They extend from inside the FSF approximately 1 meter to engage the OTV.

The fluid umbilicals are serviced by flexible hoses.

The FSF contains distribution/manifolding lines with valving and pumps to the stowage tanks.

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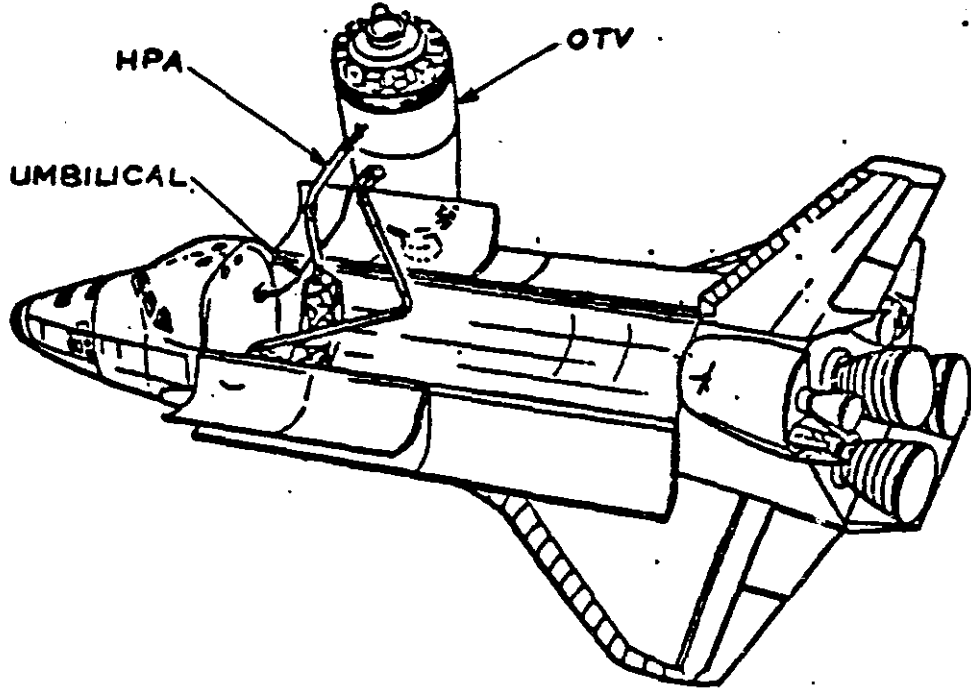
ORIGINAL PAGE 13
OF POOR QUALITY

COST ANALYSIS SHEET			
ITEM OR FUNCTION		PAGE	1 OF 3
RETRACTABLE UMBILICAL SYSTEM		REF. NO.	
PROJECT/SYSTEM		WBS NO.	
COMMSAT—ORBITER SERVICING			
ACTIVITY		NO.	4.0 & 14.0 5.0 & 15.0
CHECK OUT COMMSAT & OTV			
DESCRIPTION/SPECIFICATION/DESIGN			
SEE ATTACHMENTS FOR CONCEPT. ONLY ELECTRICAL CONNECTIONS—NO FUEL.			
		<u>DDT&E</u>	<u>\$ = M</u> <u>TFU</u>
TOTAL MASS	(KG)	<u>120</u>	
STRUCTURAL MASS	(KG) 0.263	<u>20</u>	0.143
MECHANISMS MASS	(KG) 1.321	<u>50</u>	0.869
ELECTRICAL/PD MASS	(KG)	<u> </u>	
ELECTRONIC MASS	(KG) 0.372	<u>50</u>	0.415
REQUIRED QUANTITY		<u>1</u>	
COMMENTS (DDT&E OR TECHNOLOGY STATUS)			
		\$1.956	\$1.427
CER's/FACTORS			

SERVICING ACTIVITY DATA

FUNCTION 4.0 Mate Umbilical & 5.0 Check-out	ATTACHMENT	
ITEM Comsat From Orbiter	PAGE	2 of 3
METHOD		
SUBJECT Method Description		
<ul style="list-style-type: none"> 0 RMS locks on to umbilical. 0 RMS connects umbilical to SPF. 0 Check-out of comsat functions. 		
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SERVICING ACTIVITY DATA

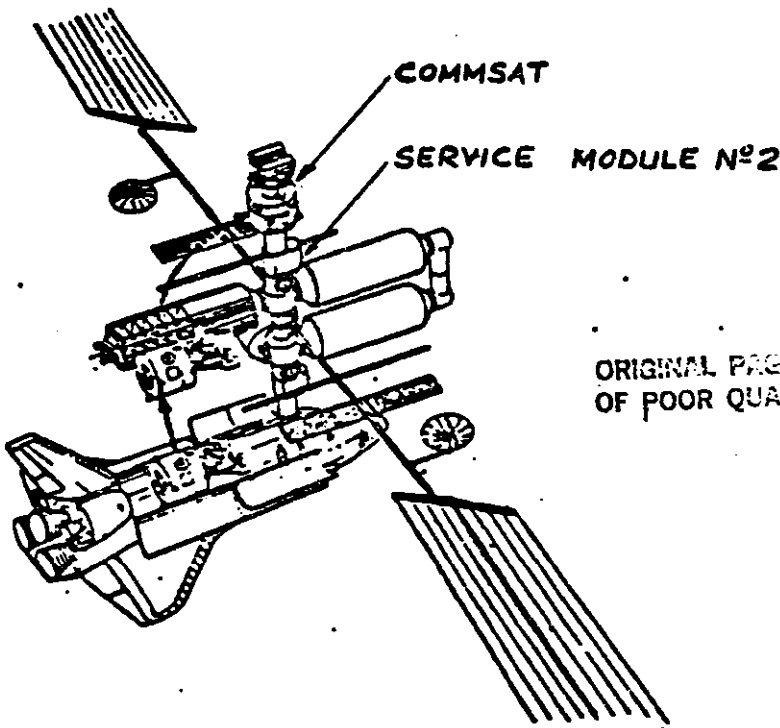
FUNCTION 14.0 Mate Umbilical & 15.0 Check-out ITEM OTV	ATTACHMENT	
METHOD From Orbiter	PAGE	3 of 3
SUBJECT Method Description		
		
<p>0 RMS picks-up umbilical & connects same to OTV</p> <p>0 All OTV systems checked-out</p> <p>ORIGINAL PAGE IS OF POOR QUALITY</p>		

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COST ANALYSIS SHEET			
ITEM OR FUNCTION COMMSAT CONTROL & MONITOR STATION		PAGE	1 OF 1
		REF. NO.	
PROJECT/SYSTEM COMMSAT—ORBITER SERVICING		WBS NO.	
		NO.	5.0 THROUGH 8.0 15.0 & 18.0
ACTIVITY C/O OF COMMSAT & OTV			
DESCRIPTION/SPECIFICATION/DESIGN CHECKOUT OF COMMSAT & OTV WOULD BE CONTROLLED AND MONITORED FROM STATION IN AFT FLIGHT DECK.			
		<u>DDT&E</u>	<u>\$ - M</u>
			<u>TFU</u>
TOTAL MASS	(KG)	1000	
STRUCTURAL MASS	(KG) 1.169	800	0.792
MECHANISMS MASS	(KG)		
ELECTRICAL/PD MASS	(KG)		
ELECTRONIC MASS	(KG) 1.076	200	1.346
REQUIRED QUANTITY		1	
COMMENTS (DDT&E OR TECHNOLOGY STATUS)			
		\$2.245	\$2.138
CER'S/FACTORS			

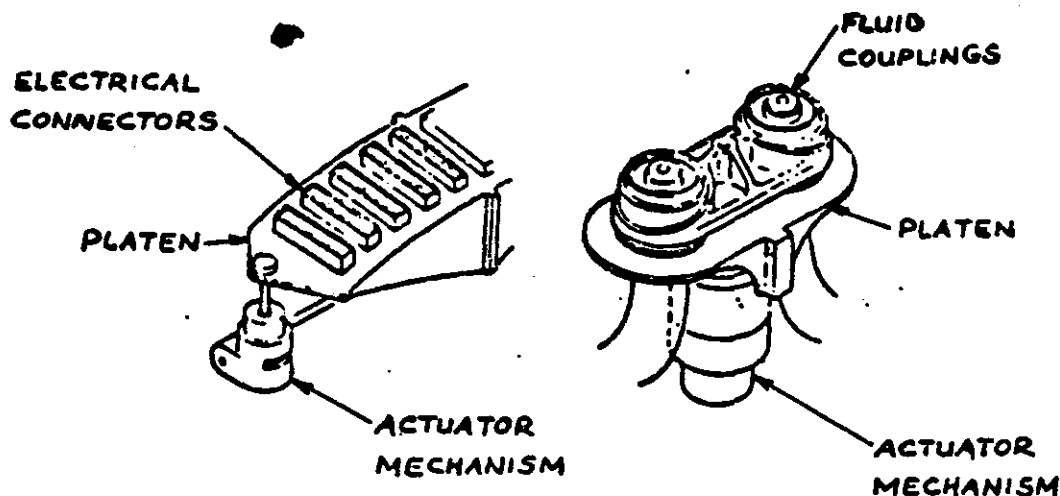
COST ANALYSIS SHEET			
ITEM OR FUNCTION RETRACTABLE UMBILICAL SYSTEM		PAGE	1 OF 3
		REF. NO.	
PROJECT/SYSTEM COMMSAT—SOC SERVICING		WBS NO.	
		NO.	6.0 THROUGH 9.0
ACTIVITY C/O COMMSAT & DEPLOY APPENDAGES			
DESCRIPTION/SPECIFICATION/DESIGN ELECTRICAL UMBILICAL ONLY. INTERFACE MUST BE THROUGH END PORT OF SERVICE MODULE NO. 2.			
		<u>DDT&E</u>	<u>\$ = M</u>
			<u>TFU</u>
TOTAL MASS	(KG)	25	
STRUCTURAL MASS	(KG) 0.091	5	0.044
MECHANISMS MASS	(KG) 0.385	10	0.222
ELECTRICAL/PD MASS	(KG)		
ELECTRONIC MASS	(KG) 0.109	10	0.075
REQUIRED QUANTITY			
COMMENTS (DDT&E OR TECHNOLOGY STATUS)			
		\$0.585	\$0.341
INTERFACE CONNECTION SIMILAR TO THAT ON DOCKING MODULE OF ORBITER. SEE ATTACHED SKETCHES.			
CER'S/FACTORS			
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SERVICING ACTIVITY DATA

FUNCTION ITEM	2.0 Thru 5.0 Maneuver & Mate to SOC Comsat	ATTACHMENT		
METHOD	From Orbiter to SOC	PAGE	2 of 3	
SUBJECT Method Description				
 <p data-bbox="1037 831 1281 905">ORIGINAL PAGE IS OF POOR QUALITY</p>				
<ul style="list-style-type: none"> 0 RMS activated locks on to comsat. 0 PIDA devices release comsat. 0 RMS translate comsat towards service fixture. 0 RMS stabilizes comsat while service fixture manipulator is activated and locks on to same. 0 RMS releases comsat & returns to orbiter. 0 Manipulator transfers comsat to end ducking port. 0 Manipulator performs berthing operation. 0 Systems mated thru docking port interface. 				

SERVICING ACTIVITY DATA

FUNCTION ITEM	(8.0) Separation of Crew Module from OTV Core MOTV/OTV	ATTACHMENT		
METHOD	N/A	PAGE	3 of 3	
SUBJECT	Typical Separation Mechanism concepts			



REMOTE ACTUATED INTERFACE CONNECTORS CONCEPTS

Three types of mechanisms are required to separate the crew module from the avionics/propulsion module. The first type is a set of solenoid operated latches similar to those utilized in docking mechanisms. Their main function is to maintain a structural connection between the crew module and the core. The other two types are functionally similar in that each consists of a motorized actuator driving acme screws to which attached is a platten that supports the electrical or fluid connections as illustrated above. These active halves of the interfaces will be located on the crew module side. The other halves, on the avionics/propulsion core module will be passive devices that accepts the illustrated plattens. Appropriate guides and alignment pins will be incorporated into the plattens.

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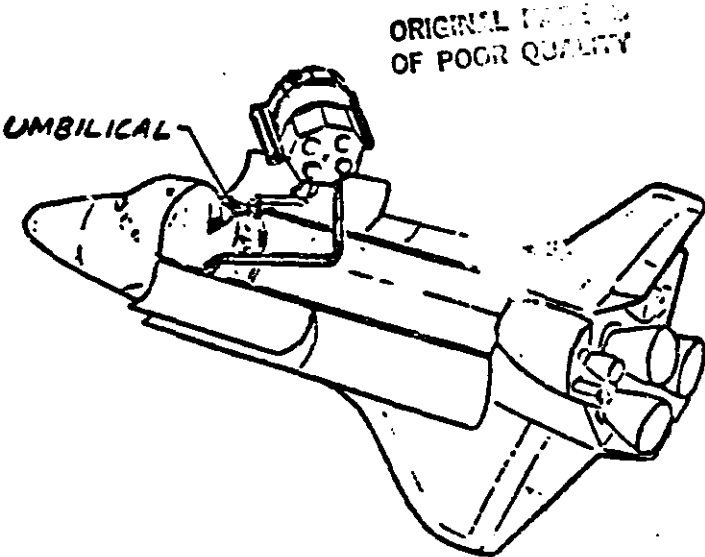
COST ANALYSIS SHEET

ITEM OR FUNCTION COMMSAT CONTROL & MONITOR STATION ON SOC (SOFTWARE & ITS STORAGE ONLY)	PAGE REF. NO.	1 OF 1																		
PROJECT/SYSTEM COMMSAT—SOC SERVICING	WBS NO.																			
ACTIVITY C/O & DEPLOYMENT OF APPENDAGES	NO.	6.0 THROUGH 9.0 & 19.0																		
DESCRIPTION/SPECIFICATION/DESIGN CONTROL STATION & COMPUTERS WOU' D BE STANDARD EQUIPMENT ON BOARD SOC, BUT DEDICATED COMMSAT CHECKOUT SOFTWARE WOULD BE REQUIRED.																				
<table> <tr> <td>TOTAL MASS</td> <td>(KG)</td> <td><u>10</u></td> </tr> <tr> <td>STRUCTURAL MASS</td> <td>(KG)</td> <td><u> </u></td> </tr> <tr> <td>MECHANISMS MASS</td> <td>(KG)</td> <td><u> </u></td> </tr> <tr> <td>ELECTRICAL/PD MASS</td> <td>(KG)</td> <td><u> </u></td> </tr> <tr> <td>ELECTRONIC MASS</td> <td>(KG)</td> <td><u> </u></td> </tr> <tr> <td>REQUIRED QUANTITY</td> <td></td> <td><u>1</u></td> </tr> </table>			TOTAL MASS	(KG)	<u>10</u>	STRUCTURAL MASS	(KG)	<u> </u>	MECHANISMS MASS	(KG)	<u> </u>	ELECTRICAL/PD MASS	(KG)	<u> </u>	ELECTRONIC MASS	(KG)	<u> </u>	REQUIRED QUANTITY		<u>1</u>
TOTAL MASS	(KG)	<u>10</u>																		
STRUCTURAL MASS	(KG)	<u> </u>																		
MECHANISMS MASS	(KG)	<u> </u>																		
ELECTRICAL/PD MASS	(KG)	<u> </u>																		
ELECTRONIC MASS	(KG)	<u> </u>																		
REQUIRED QUANTITY		<u>1</u>																		
COMMENTS (DDT&E OR TECHNOLOGY STATUS) <div align="right">\$2,000,000</div>																				
CER'S/FACTORS <div align="center">ORIGINAL FILE OF POOR QUALITY</div>																				

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COST ANALYSIS SHEET			
ITEM OR FUNCTION UMBILICAL		PAGE	1 OF 1
		REF. NO.	
PROJECT/SYSTEM SPF—ORBITER SERVICING		WBS NO.	
ACTIVITY MATE UMBILICAL		NO.	
DESCRIPTION/SPECIFICATION/DESIGN SEE ATTACHMENT—ELECTRICAL CONNECTIONS ONLY.			
		<u>DDT&E</u>	<u>\$ - M</u> <u>TFU</u>
TOTAL MASS	(KG)	<u>120</u>	
STRUCTURAL MASS	(KG) 0.263	<u>20</u>	0.143
MECHANISMS MASS	(KG) 1.321	<u>50</u>	0.869
ELECTRICAL/PD MASS	(KG)	<u> </u>	
ELECTRONIC MASS	(KG) 0.372	<u>50</u>	0.293
REQUIRED QUANTITY		<u>1</u>	
COMMENTS (DDT&E OR TECHNOLOGY STATUS)			
		\$1.956	\$1.305
CER'S/FACTORS			

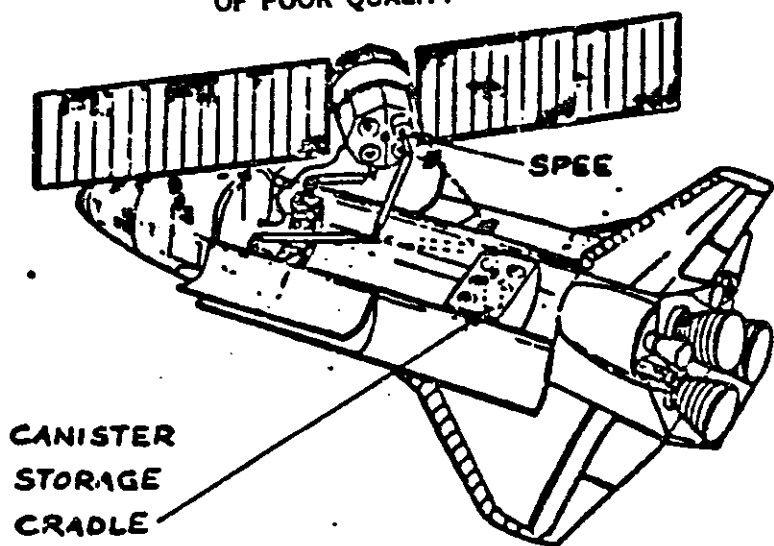
SERVICING ACTIVITY DATA

FUNCTION ITEM	3.0 Berth & 4.0 Mate Umbilical Space Processing Facility From Orbiter	ATTACHMENT		
METHOD		PAGE	2 of 2	
SUBJECT	Method Description			
				
<ul style="list-style-type: none"> 0 Berth SPF to HPA via RMS. 0 RMS locks on to umbilical. 0 RMS connects umbilical to SPF. 				

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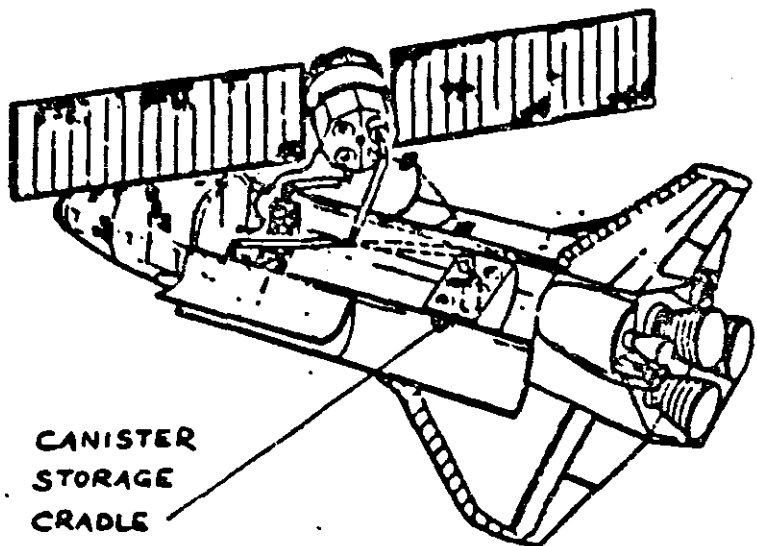
COST ANALYSIS SHEET			
ITEM OR FUNCTION SPECIAL PURPOSE END EFFECTOR (SPEE)		PAGE	1 OF 2
		REF. NO.	
PROJECT/SYSTEM SPF—ORBITER SERVICING		WBS NO.	
		NO.	17.0 & 19.0
ACTIVITY DEPLOY & STOW EXPERIMENT CANISTERS			
DESCRIPTION/SPECIFICATION/DESIGN			
SPECIAL-PURPOSE END EFFECTOR NEEDED TO EXTRACT & STOW EXPERIMENT CANISTER AS SHOWN ON ATTACHED SKETCH.			
		<u>DDT&E</u>	<u>\$ - M</u> <u>TFU</u>
TOTAL MASS	(KG)	35	
STRUCTURAL MASS	(KG) 0.351	15	0.142
MECHANISMS MASS	(KG) 0.758	18	0.404
ELECTRICAL/PD MASS	(KG)		
ELECTRONIC MASS	(KG) 0.234	2	0.036
REQUIRED QUANTITY		1	
COMMENTS (DDT&E OR TECHNOLOGY STATUS)			
		\$1.343	\$0.582
SPEE IS SIMILAR IN SIZE, WEIGHT, & COMPLEXITY TO STANDARD GRAPPLE END EFFECTOR.			
CER'S/FACTORS			

SERVICING ACTIVITY DATA

FUNCTION ITEM	3.0 Berth & 4.0 Mate Umbilical Space Processing Facility From Orbiter	ATTACHMENT	
METHOD		PAGE	2 of 2
SUBJECT Method Description			
<p data-bbox="650 491 898 575">ORIGINAL PAGE IS OF POOR QUALITY</p> 			
<ul style="list-style-type: none"> <li data-bbox="337 1289 733 1331">0 Berth SPF to HPA via RMS. <li data-bbox="337 1352 766 1394">0 RMS locks on the umbilical. <li data-bbox="337 1415 816 1457">0 RMS connects umbilical to SPF. 			

COST ANALYSIS SHEET																											
ITEM OR FUNCTION MODULE & CANISTER STORAGE & RETRIEVAL	PAGE 1 OF 2																										
	REF. NO.																										
PROJECT/SYSTEM SPF—ORBITER SERVICING	WBS NO.																										
ACTIVITY DEPLOY & STOW EXPERIMENT CANISTERS	NO.	17.0 & 19.0																									
DESCRIPTION/SPECIFICATION/DESIGN STORAGE MODULE COULD BE A CRADLE WITH CAVITIES FOR STORING EXPERIMENT CANISTERS. SEE SKETCH.																											
<div style="display: flex; justify-content: space-around;"> <u>DDT&E</u> <u>S = M</u> <u>TFU</u> </div>																											
<table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 40%;">TOTAL MASS</td> <td style="width: 10%;">(KG)</td> <td style="width: 20%; text-align: right;">1633</td> <td style="width: 30%;"></td> </tr> <tr> <td>STRUCTURAL MASS</td> <td>(KG) 1.767</td> <td style="text-align: right;">1497</td> <td style="text-align: right;">1.348</td> </tr> <tr> <td>MECHANISMS MASS</td> <td>(KG) 1.659</td> <td style="text-align: right;">68</td> <td style="text-align: right;">1.128</td> </tr> <tr> <td>ELECTRICAL/PD MASS</td> <td>(KG)</td> <td></td> <td></td> </tr> <tr> <td>ELECTRONIC MASS</td> <td>(KG) 2.919</td> <td style="text-align: right;">68</td> <td style="text-align: right;">0.845</td> </tr> <tr> <td>REQUIRED QUANTITY</td> <td></td> <td style="text-align: right;">1</td> <td></td> </tr> </table>				TOTAL MASS	(KG)	1633		STRUCTURAL MASS	(KG) 1.767	1497	1.348	MECHANISMS MASS	(KG) 1.659	68	1.128	ELECTRICAL/PD MASS	(KG)			ELECTRONIC MASS	(KG) 2.919	68	0.845	REQUIRED QUANTITY		1	
TOTAL MASS	(KG)	1633																									
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ELECTRONIC MASS	(KG) 2.919	68	0.845																								
REQUIRED QUANTITY		1																									
COMMENTS (DDT&E OR TECHNOLOGY STATUS) <div style="display: flex; justify-content: space-between; margin-top: 10px;"> \$6.345 \$3.321 </div> <div style="text-align: center; margin-top: 20px;"> ORIGINAL PAGE IS OF POOR QUALITY </div>																											
CER's/FACTORS																											

SERVICING ACTIVITY DATA

FUNCTION ITEM	17.0 thru 19.0 Cannister Changeout Space Processing Facility From Orbiter	ATTACHMENT		
METHOD	PAGE	2 of 2		
SUBJECT Method Description				
<p data-bbox="683 491 915 554">ORIGINAL PHOTO IS OF POOR QUALITY</p>  <p data-bbox="535 974 700 1079">CANISTER STORAGE CRADLE</p>				
<ul style="list-style-type: none"> 0 RMS locks on to used SPF canister. 0 RMS translates canister to orbiter bay. 0 Canister insterted into storage unit. 0 RMS removes new materials canister. 0 Canister inserted into empty SPF orific. 0 RMS locks on to next used canister & above procedure repeated until all canisters have been exchanged. 				

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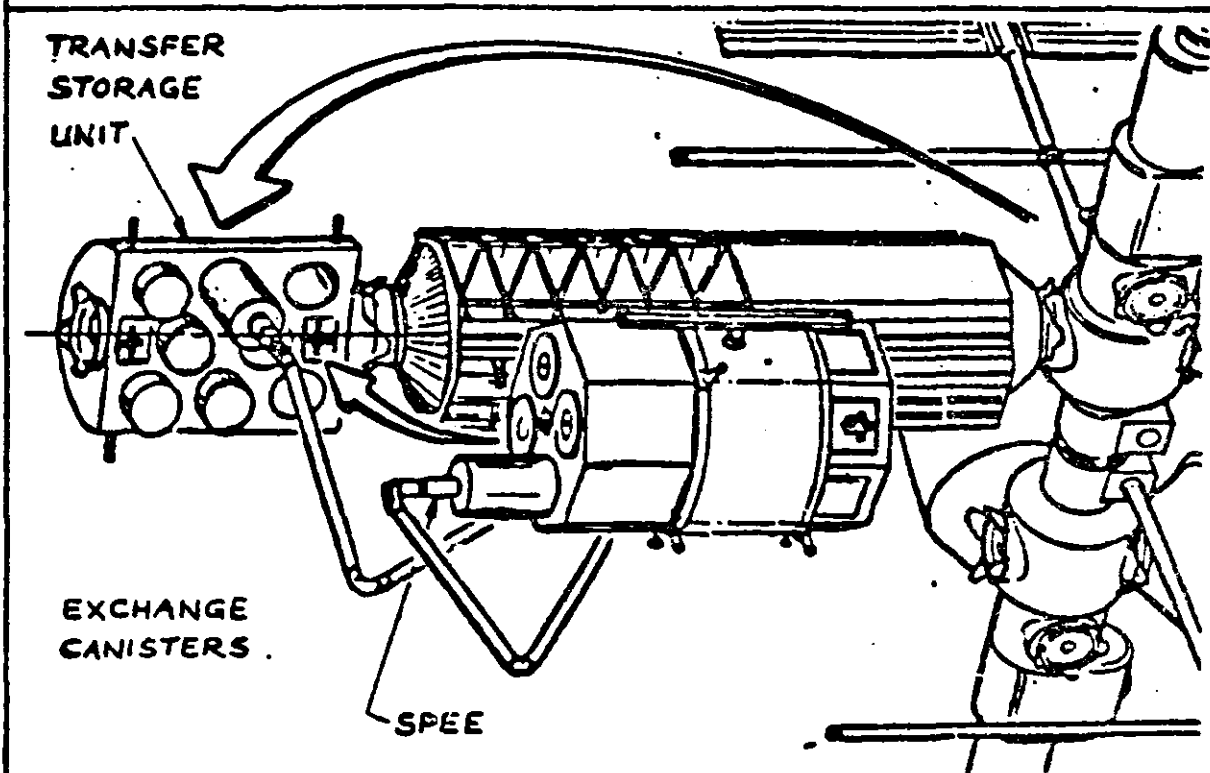
COST ANALYSIS SHEET			
ITEM OR FUNCTION		PAGE	1 OF 1
SPF CONTROL & MONITOR STATION		REF. NO.	
PROJECT/SYSTEM		WBS NO.	
SPF—ORBITER SERVICING			
ACTIVITY		NO.	5.0, 12.0 THROUGH 21.0
CHECK OUT SPF			
DESCRIPTION/SPECIFICATION/DESIGN			
CHECKOUT OF SPF WOULD BE CONTROLLED FROM STATION IN AFT FLIGHT DECK.			
		<u>DDT&E</u>	<u>\$ - M</u> <u>TFU</u>
TOTAL MASS (KG)		<u>1000</u>	
STRUCTURAL MASS (KG) 3.587		<u>800</u>	2.970
MECHANISMS MASS (KG)		<u> </u>	
ELECTRICAL/PD MASS (KG)		<u> </u>	
ELECTRONIC MASS (KG) 8.487		<u>200</u>	1.397
REQUIRED QUANTITY		<u>1</u>	
COMMENTS (DDT&E OR TECHNOLOGY STATUS)			
		\$12.074	\$4.367
CER'S/FACTORS			

COST ANALYSIS SHEET																				
ITEM OR FUNCTION SPF CONTROL & MONITOR STATION ON SOC (SOFTWARE & ITS STORAGE ONLY)	PAGE	1 OF 1																		
	REF. NO.																			
PROJECT/SYSTEM SPF—SOC SERVICING	WBS NO.																			
ACTIVITY CHECKOUT & SERVICING OF SPF	NO.																			
DESCRIPTION/SPECIFICATION/DESIGN CONTROL STATION & COMPUTERS WOULD BE STANDARD EQUIPMENT ON BOARD SOC. ONLY DEDICATED SPF SOFTWARE WOULD BE NEEDED. ORIGINAL PAGE IS OF POOR QUALITY																				
<table> <tbody> <tr> <td>TOTAL MASS</td> <td>(KG)</td> <td>10</td> </tr> <tr> <td>STRUCTURAL MASS</td> <td>(KG)</td> <td></td> </tr> <tr> <td>MECHANISMS MASS</td> <td>(KG)</td> <td></td> </tr> <tr> <td>ELECTRICAL/PD MASS</td> <td>(KG)</td> <td></td> </tr> <tr> <td>ELECTRONIC MASS</td> <td>(KG)</td> <td></td> </tr> <tr> <td>REQUIRED QUANTITY</td> <td></td> <td></td> </tr> </tbody> </table>			TOTAL MASS	(KG)	10	STRUCTURAL MASS	(KG)		MECHANISMS MASS	(KG)		ELECTRICAL/PD MASS	(KG)		ELECTRONIC MASS	(KG)		REQUIRED QUANTITY		
TOTAL MASS	(KG)	10																		
STRUCTURAL MASS	(KG)																			
MECHANISMS MASS	(KG)																			
ELECTRICAL/PD MASS	(KG)																			
ELECTRONIC MASS	(KG)																			
REQUIRED QUANTITY																				
COMMENTS (DDT&E OR TECHNOLOGY STATUS) \$2,000,000																				
CER'S/FACTORS																				

COST ANALYSIS SHEET			
ITEM OR FUNCTION SPECIAL PURPOSE END EFFECTOR (SPEE)		PAGE	1 OF 2
		REF. NO.	
PROJECT/SYSTEM SPF—SOC SERVICING		WBS NO.	
ACTIVITY DEPLOY & STOW EXPERIMENT CANISTERS		NO.	11.0 THROUGH 15.0
DESCRIPTION/SPECIFICATION/DESIGN SEE ATTACHED SKETCH.			
		<u>DDT&E</u>	<u>\$ M</u> <u>TFU</u>
TOTAL MASS (KG)		35	
STRUCTURAL MASS (KG) 0.351		15	0.142
MECHANISMS MASS (KG) 0.758		18	0.404
ELECTRICAL/PD MASS (KG)			
ELECTRONIC MASS (KG) 0.234		2	0.036
REQUIRED QUANTITY		1	
COMMENTS (DDT&E OR TECHNOLOGY STATUS)			
		\$1.343	\$0.582
SPEE SIMILAR IN SIZE, WEIGHT & COMPLEXITY TO STANDARD GRAPPLE END EFFECTOR.			
CER's/FACTORS			
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SERVICING ACTIVITY DATA

FUNCTION ITEM	11.0 thru 15.0 Change-out items Space Processing Facility	ATTACHMENT	
		PAGE	2 of 2
METHOD	By SOC		
SUBJECT	Method Description		



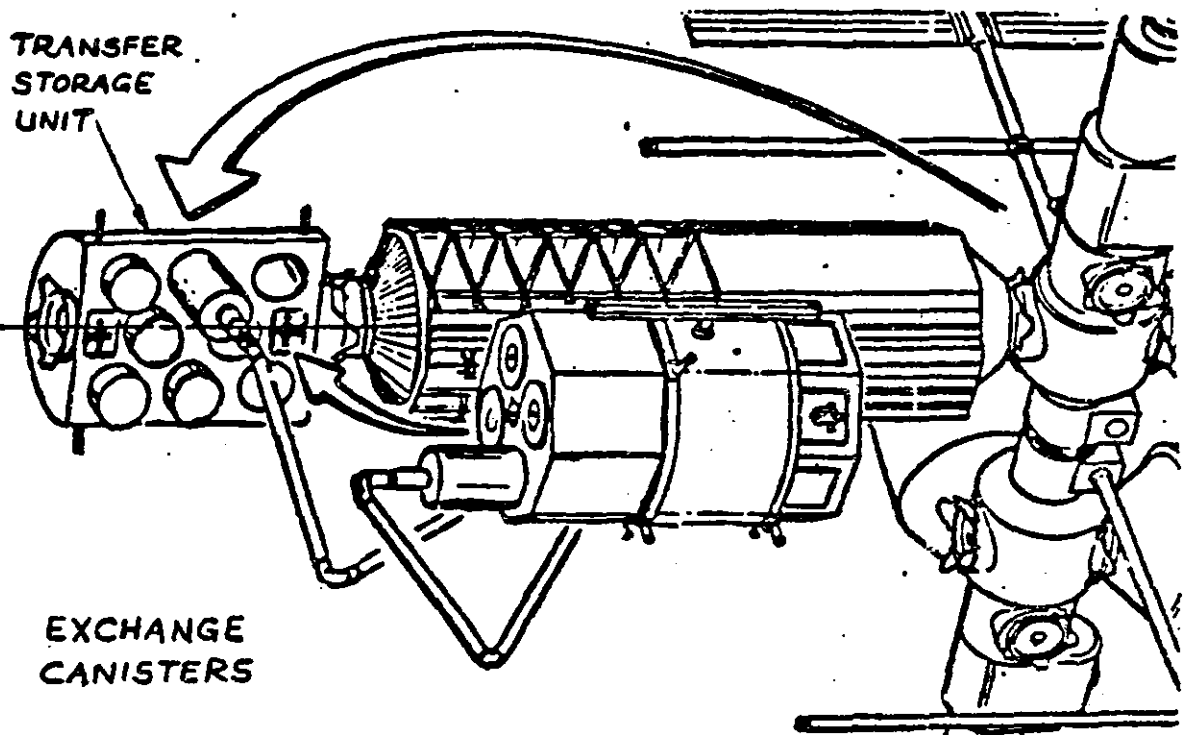
- 0 Manipulator transfers storage unit from its stowed location (i.e. spare docking port or resupply by orbiter) & berths same to service fixtures end docking port.
- 0 Manipulator locks on to used canister & transfers same to storage unit.
- 0 A new canister is removed from the storage unit & placed into the empty SPF orific.
- 0 Manipulator removes 2nd used canister, repeating procedure until all canisters have been exchanged.
- 0 SPF systems check out.
- 0 Manipulator exchanges consumables with EVA assist.

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COST ANALYSIS SHEET					
ITEM OR FUNCTION MODULE & CANISTER STORAGE & RETRIEVAL SYSTEM		PAGE	1 OF 2		
		REF. NO.			
PROJECT/SYSTEM SPF-SOC SERVICING		WBS NO.			
ACTIVITY DEPLOY & STOW EXPERIMENT CANISTERS		NO.	11.0 THROUGH 15.0		
DESCRIPTION/SPECIFICATION/DESIGN					
MODULE COULD BE A CRADLE, BUT WITH BERTHING PORTS ON BOTH ENDS AS SEEN IN ATTACHED SKETCH.					
		<u>DDT&E</u>	<u>\$ - M</u>	<u>RECURRING</u>	<u>TFU</u>
TOTAL MASS (KG)		<u>1633</u>			
STRUCTURAL MASS (KG) 6.117		<u>1497</u>		10.016	5.565
MECHANISMS MASS (KG) 1.659		<u>68</u>		2.030	1.128
ELECTRICAL/PD MASS (KG)		<u> </u>			
ELECTRONIC MASS (KG) 2.919		<u>68</u>		1.520	0.845
REQUIRED QUANTITY		<u>2</u>			
COMMENTS (DDT&E OR TECHNOLOGY STATUS)					
		\$10.695	\$13.566	\$7.538	
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CER's/FACTORS					

SERVICING ACTIVITY DATA

FUNCTION 11.0 thru 15.0 Change-out items		ATTACHMENT	
ITEM Space Processing Facility			
METHOD by SOC		PAGE	2 of 2
SUBJECT Method Description			



The diagram illustrates the servicing process. A robotic manipulator arm is positioned to interact with a 'TRANSFER STORAGE UNIT'. This unit is shown with multiple circular ports. Below the unit, 'EXCHANGE CANISTERS' are depicted. A curved arrow indicates the unit's movement from a stowed location to a service position. The entire assembly is supported by a structural frame.

- 0 Manipulator transfers storage unit from its stowed location (i.e. spare docking port or resupply by orbiter) & berths same to service fixtures end docking port.
- 0 Manipulator locks on to used canister & transfers same to storage unit.
- 0 A new canister is removed from the storage unit & placed into the empty SPF orific.
- 0 Manipulator removes 2nd used canister, repeating procedure until all canisters have been exchanged.
- 0 SPF systems check out.
- 0 Manipulator exchanges consumables with EVA assist.

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